MITOS SOBRE MICRONUTRIENTES

Luiz Roberto Guimarães Guilherme, PhD

guilherm@dcs.ufla.br

São Paulo (SP), 25/11/2010

UNIVERSIDADE FEDERAL DE LAVRAS

Universidade Federal de Lavras
Departamento de Ciência do Solo

DCS

Pontos a Discutir: Mitos ou Fatos?

- Fome e desnutrição no Mundo
- Micronutrientes essenciais
  - Foco em nutrição mineral de plantas?
- Deficiência generalizada de nutrientes nos solos tropicais justifica a preocupação com micronutrientes
  - A "Lei do Mínimo" e as interações
- Uso de micronutrientes: a recomendação agronômica e as exceções
  - Dose *vs* Variabiliadade Ambiental (solos) e Genética
- A procura da melhor fonte/método de aplicação
  - Existe "a melhor"?
- Quantidade = Qualidade?
  - Pesquisas em bioacessibilidade
- Considerações finais

UNIVERSIDADE FEDERAL DE LAVRAS

Fome e desnutrição no Mundo

UNIVERSIDADE FEDERAL DE LAVRAS

O Grande Desafio Mundial

	1990	2000	2025
POPULAÇÃO MUNDIAL (BILHÕES)	*5,2*	*6,2*	*8,3*
DEMANDA DE ALIMENTOS (BILHÕES t)	*1,97*	*2,45*	*3,97*
PRODUTIVIDADE (t/ha)	*2,5*	*2,9*	*4,5*

Fonte: Bourlaug e Dowswell (1993)

Copenhagen Consensus 2008

Painel com 8 dos mais renomados economistas mundiais

Meta: fixar prioridades dentre umas série de propostas para confrontar dez grandes desafios globais

- Poluição do ar
- Conflitos
- Doenças
- Educação
- Aquecimento Global
- Desnutrição e Fome
- Saneamento Básico
- Subsídios e Barreiras Comerciais
- Terrorismo
- Mulheres e Desenvolvimento

Propostas: relação benefício/custo

Copenhagen Consensus 2008

SOLUÇÃO (em ordem de prioridade)	DESAFIO
1. Suplementação de crianças (vitamina A e zinco)	Desnutrição
2. O Acordo de Doha	Comércio
3. Fortificação com micronutrientes (ferro e sal iodado)	Desnutrição
4. Expandir programas de imunização de crianças	Doenças
5. Biofortificação	Desnutrição
6. Combate a verminose e outros programas nutricionais	Desnutrição e Educação
7. Redução de preço de mensalidades escolares	Educação
8. Aumento e melhoria da educação de meninas	Mulheres
9. Programas comunitários de promoção da nutrição	Desnutrição
10. Prover suporte a mulheres durante a gestação	Mulheres

Biofortificação *vs* Segurança Alimentar na Índia

Zinc biofortification of food grains in relation to food security and alleviation of zinc malnutrition

Rajendra Prasad

Exemplary agricultural research supported by good governme
in India. It is the right time to focus on micronutrient malnutri
ciency in diet especially of young children below 5 years of a
deficiency diseases in infants and children include diarrhoe
immune system and retarded mental growth. Zn deficiency i
problems and even mortality in infants. Over 450 thousand in
were ascribed to Zn deficiency. Although Zn deficiency to son
mentation and improvement in dietary composition, it is better
the staple food in India and as a matter of fact in the entire s
achieved by biofortification of foodgrains either by developing
tion of Zn in grains or by adequate Zn fertilization of crops g
also suffer from Zn malnutrition.

Keywords: Biofortification, food security, zinc malnutrition.

SINCE gaining independence in 1947, India's main thrust in agricultural research has been on food security and rightly so, because India has a history of devastating famines in the 19th century[1] and a virtual famine in 1966 which was averted through import of 10 million tonnes of wheat from USA under PL480 programme[2]. India's food grain production improved after the introduction of high yielding dwarf fertilizer responsive varieties of wheat during 1966–68. With a matching progress in the manufacture and consumption of fertilizers, increase in the area under irrigation and development of rural infrastructure, such as, roads, schools, etc., it has been possible to achieve food security in the country. There is of course no room for complacency and sincere efforts for maintaining food security must continue on all fronts (production, availability, access and absorption)[3]. Nevertheless it is high time that along with food security due attention is also paid to adequate micronutrient nutrition in India. The micronutrients in human and animal nutrition include vitamins (A, B, C, D, E and K) and 17 microminerals (Fe, Zn, Cu, Mn, I, Fl, B, Se, Mo, Ni, Cr, V, Si, As, Li, Sn, Co). Plants require only seven essential micronutrients (Fe, Mn, Zn, Cu, B, Mo, Cl).

Major micr

Globally thr
been recogniz
ficiency lead
children in In
(ii) iron defic
kids between
between 15 a
(iii) iodine d
endemic in 8
ciency of Zn
on global mo
to different n
in Table 1. V
maximum nu
ciencies.

Table 1. Global mortality in children under 5 years of age in 2004

Deficiency	Deaths
Vitamin A	666,771
Zinc	453,207
Iron	20,854
Iodine	3,619

Source: Black *et al.*[7].

Rajendra Prasad lives at C-309, Vardhman Apartments, Mayur Vihar Extension, Phase 1, New Delhi 110 091, India.
e-mail: rajuma36@gmail.com

Exemplary agricultural research supported by good government policies has ensured food security in India. **It is the right time to focus on micronutrient malnutrition in the country**…

… Although Zn deficiency to some extent can be cured by Zn supplementation and improvement in dietary composition, **it is better to increase the Zn content in cereals**, the staple food in India and as a matter of fact in the entire south and southeast Asia. This can be achieved by **biofortification of foodgrains** either by developing **crop cultivars** with high concentration of Zn in grains or by **adequate Zn fertilization** of crops grown on Zn-deficient soils. Animals also suffer from Zn malnutrition.

UFLA UNIVERSIDADE FEDERAL DE LAVRAS

Alimentação *vs* Nutrição

Quantidade *vs* Qualidade

Calton *Journal of the International Society of Sports Nutrition* 2010, **7**:24
http://www.jissn.com/content/7/1/24

jissn
journal of the international society of sports nutrition™

RESEARCH ARTICLE **Open Access**

Prevalence of micronutrient deficiency in popular diet plans

Jayson B Calton

Abstract

Background: Research has shown micronutrient deficiency to be scientifically linked to a higher risk of overweight/obesity and other dangerous and debilitating diseases. With more than two-thirds of the U.S. population overweight or obese, and research showing that one-third are on a diet at any given time, a need existed to determine whether current popular diet plans could protect followers from micronutrient deficiency by providing the minimum levels of 27 micronutrients, as determined by the U.S. Food and Drug Administrations (FDA) Reference Daily Intake (RDI) guidelines.

UFLA
UNIVERSIDADE FEDERAL DE LAVRAS

Insegurança alimentar causada por baixa qualidade de alimentos

Food Sec. (2009) 1:431–440
DOI 10.1007/s12571-009-0039-6

REVIEW

Incorporating nutritional considerations when addressing food insecurity

Prakash Shetty

Received: 23 February 2009 / Accepted: 7 (

Abstract Addressing the challenges (
will benefit from the simultaneous i
tional priorities that contribute to
populations. Inclusion of nutritional
increasing availability and access t

Agricultural approaches to improve the nutrient content of crops have included field fortification strategies, which enhance the micronutrient and trace element content of crops by applying enriched fertilizers to the soil. There is good evidence that deficiencies and excesses of micronutrients and trace elements in soils have a profound impact on the well-being of plants and animals that depend on soil to thrive (Lal 2009). Enrichment of soil with fertilizers fortified with micronutrients and trace elements to increase their content in cereal grains has been attempted for selenium, iodine and zinc and in the case of iron to enhance its content in leaves. The best studies showing soil

UNIVERSIDADE FEDERAL DE LAVRAS

Adubação com Se

Current Nutrition & Food Science, 2010, *6*, 000-000 1

Selenium Deficiency in Soils and Crops and its Impact on Animal and Human Health

Umesh C. Gupta[1,*] and Subhas C. Gupta[2]

[1]*Agriculture and Agri-Food Canada, Crops and Livestock Research Centre, Charlottetown, P.E.I., Canada C1A 4N6, Canada*

[2]*The Department of Plastic Surgery, Loma Linda University and Chief of Surgical Services, Loma Linda University Medical Center, Loma Linda, California 92354, United States of America*

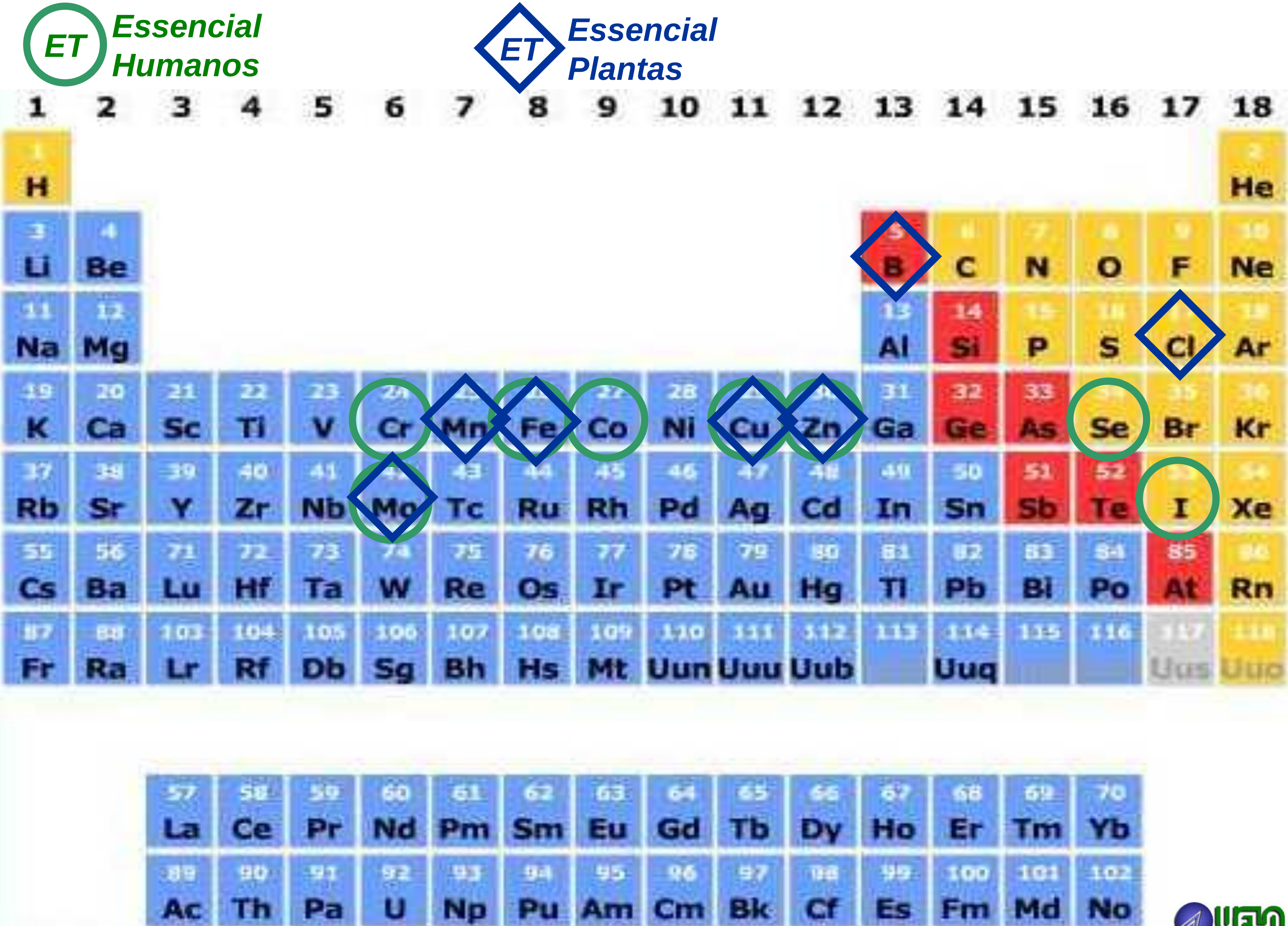
Abstract: Selenium (Se) content in soils varies greatly depending upon the parent rock, weathering, pH and texture. In general, total soil Se content of 0.1 to 0.6 mg kg^{-1} is considered deficient. Selenium deficiency regions in New Zealand, Denmark and the Atlantic Region of Canada contain 0.1 to 0.6 mg Se kg^{-1} in the soil. Soil acidity is an important factor resulting in decreased Se availability to crops. Selenium concentration in plants can range from 0.005 mg kg^{-1} in deficient crops to more than 1000 mg kg^{-1} in Se accumulators on seleniferous soils. Brassicas and legumes, particularly soybeans, contain higher Se than other crops. Selenium fertilization of crops is now permitted in a few countries, such as, New Zealand, Finland and to a limited extent in China, the United States, and Canada. Feed crops containing more than 0.1 mg Se kg^{-1} should protect livestock from Se deficiency disorders. Selenium is an essential mineral for livestock as well as for humans, but its essentiality for the growth of cultivated crops has so far not been demonstrated. Inadequate Se in animal rations can cause white muscle disease in calves, sheep and goat, exudative diathesis in poultry and mulberry heart disease in pigs. Selenium deficiency can be prevented by Se injections to females at late gestation and/or to the young stock shortly after birth. In humans, lack of Se has been linked to several kinds of cancer, heart disease and other chronic and life threatening conditions. Adequate Se nutrition supports efficient thyroid hormone synthesis and metabolism and protects the thyroid gland from damage by excessive iodide exposure. Inadequate plasma Se can adversely affect the maintenance of optimal health. Selenium appears to play a key role in health maintenance of aging individuals. Oral Se therapy has been reported to produce significant decreases in lung, prostate and colorectal cancer. Selenium has been shown to help prevent cardiomyopathy in young children in China. Pills containing Se alone or in combination with vitamins and or minerals are available in several countries as human supplements. Eating Se enriched foods and animal products and/or Se pills may protect humans from pathology associated with Se deficiency.

Key Words: Soil properties, Se responsive diseases in livestock, Se deficiency in humans, Se deficiency control measures, Se sources.

UNIVERSIDADE FEDERAL DE LAVRAS

Micronutrientes essenciais

Foco em nutrição mineral de plantas?



UFLA
UNIVERSIDADE FEDERAL DE LAVRAS

Biofortificação *vs* Nutrição

Available online at www.sciencedirect.com

ScienceDirect

ELSEVIER

Current Opinion in Plant Biology

Biofortification and phytoremediation

Fang-Jie Zhao and Steve P McGrath

Producing nutritious and safe foods sufficiently and sustainably is the ultimate goal of modern agriculture. Past efforts have focused on increasing crop yields, but enhancing the concentrations of mineral micronutrients has become an urgent task because about half of the world population suffers from the malnutrition of iron, zinc, and selenium. Biofortification of these trace elements can be achieved through fertilization, crop breeding or biotechnology.

Current Opinion in Plant Biology 2009, 12:373–380

This review comes from a themed issue on Physiology and metabolism
Edited by David Salt and Lorraine Williams

Available online 25th May 2009

mineral concentrations [8,9•].

For Zn and Fe, breeding for higher concentrations in grain is possible as there is sufficient genotypic variation in the germplasms of major cereal crops [3,10,11]. Wild

Nutrir as plantas para nutrir os homens

Annals of Botany **105**: 1073–1080, 2010
doi:10.1093/aob/mcq085, available online at www.aob.oxfordjournals.org

ANNALS OF BOTANY
Founded 1887

OVERVIEW: PART OF A SPECIAL ISSUE ON PLANT NUTRITION

Plant nutrition for sustainable development and global health

P. J. White[1,*] and P. H. Brown[2]

[1]*Scottish Crop Research Institute, Invergowrie, Dundee DD2 5DA, UK and* [2]*Department of Plant Sciences, University of California, Davis, CA 95616, USA*
* *For correspondence. E-mail philip.white@scri.ac.uk*

Received: 26 February 2010 Returned for revision: 19 March 2010 Accepted: 24 March 2010 Published electronically: 29 April 2010

• *Background* Plants require at least 14 mineral elements for their nutrition. These include the macronutrients nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg) and sulphur (S) and the micronutrients chlorine (Cl), boron (B), iron (Fe), manganese (Mn), copper (Cu), zinc (Zn), nickel (Ni) and molybdenum (Mo). These are generally obtained from the soil. Crop production is often limited by low phytoavailability of essential mineral elements and/or the presence of excessive concentrations of potentially toxic mineral elements, such as sodium (Na), Cl, B, Fe, Mn and aluminium (Al), in the soil solution.

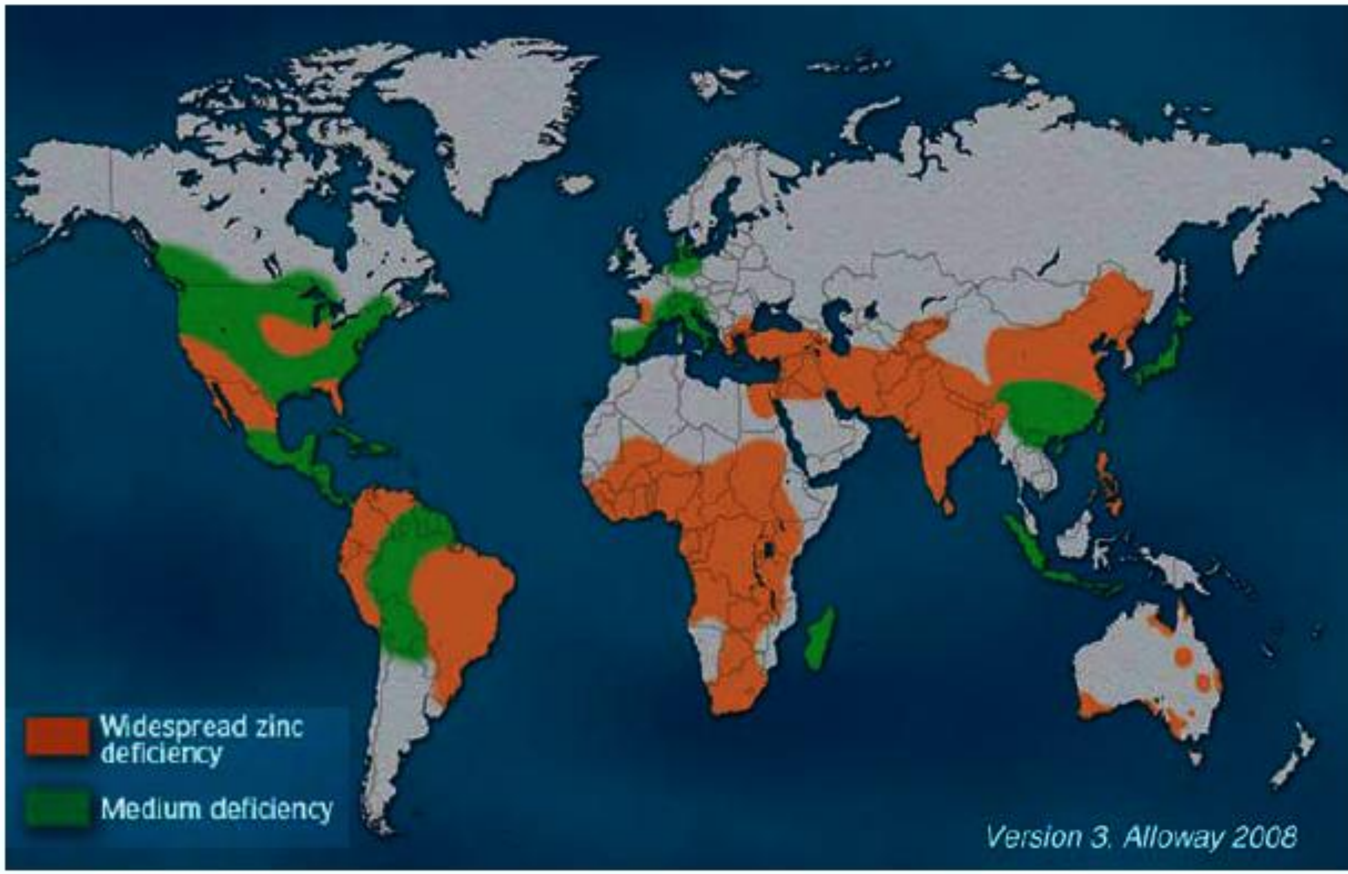
It concludes with a perspective on how agriculture can produce edible crops that contribute sufficient mineral elements for adequate animal and human nutrition.

Key words: Biofortification, fertilizer use efficiency, mineral nutrition, pollution, toxicity, transport protein.

UFLA
UNIVERSIDADE FEDERAL DE LAVRAS

Por que se preocupar com micronutrientes? Deficiência é um sério problema de segurança alimentar (e.g., o caso do Zn)

Fig. 1 Global distribution of reported cases of zinc deficiency in crops (Alloway 2008b). Reproduced with permission from the International Zinc Association (IZA) and International Fertilizer Industry Association (IFA)



Fonte: B. J. Alloway, Environ Geochem Health, 31:537-548, 2009. DOI 10.1007/s10653-009-9255-4

Micronutrientes são essenciais para as plantas

Micronutriente	Nível crítico (mg dm^{-3})	Abaixo do nível crítico (%)	Intervalo	Média
			--- (mg dm^{-3}) ---	
Cobre	1,0			
Zinco	1,0			
Manganês	5,0			
Ferro	-			

Fundação MT (2002)

Def. Cu ~43%

Def. Zn ~20%

Def. Mn ~12%

Def. B ~82%

Fonte: Yamada (2004)

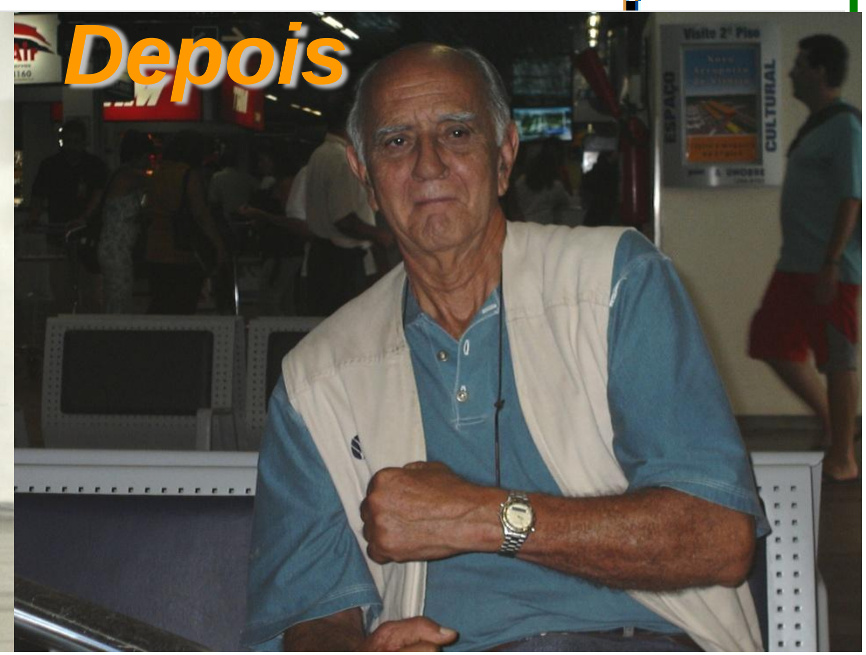
– Tecnologia de fertilizantes

– Deficiência no solo: nativa (e. 1983) ou induzida (e.g., alto pH)

– Aprimoramento da análise de solos e da análise foliar

Micronutrientes são essenciais para o ser humano

Zinc	25mg	167%
Selenium	200mcg	286%



UFLA
UNIVERSIDADE FEDERAL DE LAVRAS

Enriquecimento de alimentos com micronutrientes: biofortificação agronômica ou genética?

Plant Soil (2008) 302:1–17
DOI 10.1007/s11104-007-9466-3

MARSCHNER REVIEW

Enrichment of
or genetic biof

Ismail Cakmak

Received: 13 September 200

Abstract Zinc deficiency
lem in food crops, causi
nutritional quality. Gener
with Zn-deficient soils
widespread Zn deficiency
indicate that nearly half

- Biofortificação agronômica é uma abordagem complementar à estratégia de melhoramento genético
- Novos programas de investigação devem focar no desenvolvimento de métodos de aplicação mais eficientes de Zn para promover a maximização de absorção e acúmulo de Zn em grão
- Em caso de maior **biodisponibilidade** de Zn em grãos proveniente da aplicação foliar do que a partir do solo, a biofortificação agronômica seria uma estratégia muito atraente e útil na resolução de problemas de saúde relacionados com a deficiência de zinco.

UFLA UNIVERSIDADE FEDERAL DE LAVRAS

Deficiência generalizada de nutrientes nos solos tropicais justifica a preocupação com micronutrientes

A "Lei do Mínimo" e as interações

UNIVERSIDADE FEDERAL DE LAVRAS

Micronutrientes em solos

Trópicos *vs* Região Temperada

SETAC PRESS

Environmental Toxicology and Chemistry, Vol. 16, No. 1, pp. 75–83, 1997

Printed in the USA
0730-7268/97 $6.00 + .00

Annual Review

DEFICIENCIES AND TOXICITIES OF TRACE ELEMENTS AND MICRONUTRIENTS IN TROPICAL SOILS: LIMITATIONS OF KNOWLEDGE AND FUTURE RESEARCH NEEDS

BRIAN E. DAVIES
Department of Geological Sciences, 340 Brackett Hall, Clemson University, Clemson, South Carolina 29634-1908, USA

9 July 1996)

nd toxicities of trace elements and micronutrients in
or is challenged. Continuing use of the term "laterite"
The trace element content of plinthite and its possible
is of tropical agriculture are related to soil type and
cussed in both agricultural and ecological contexts.
supplement the emerging picture of the complexities
mulated studies of the element in tropical soils, and

Toxicities

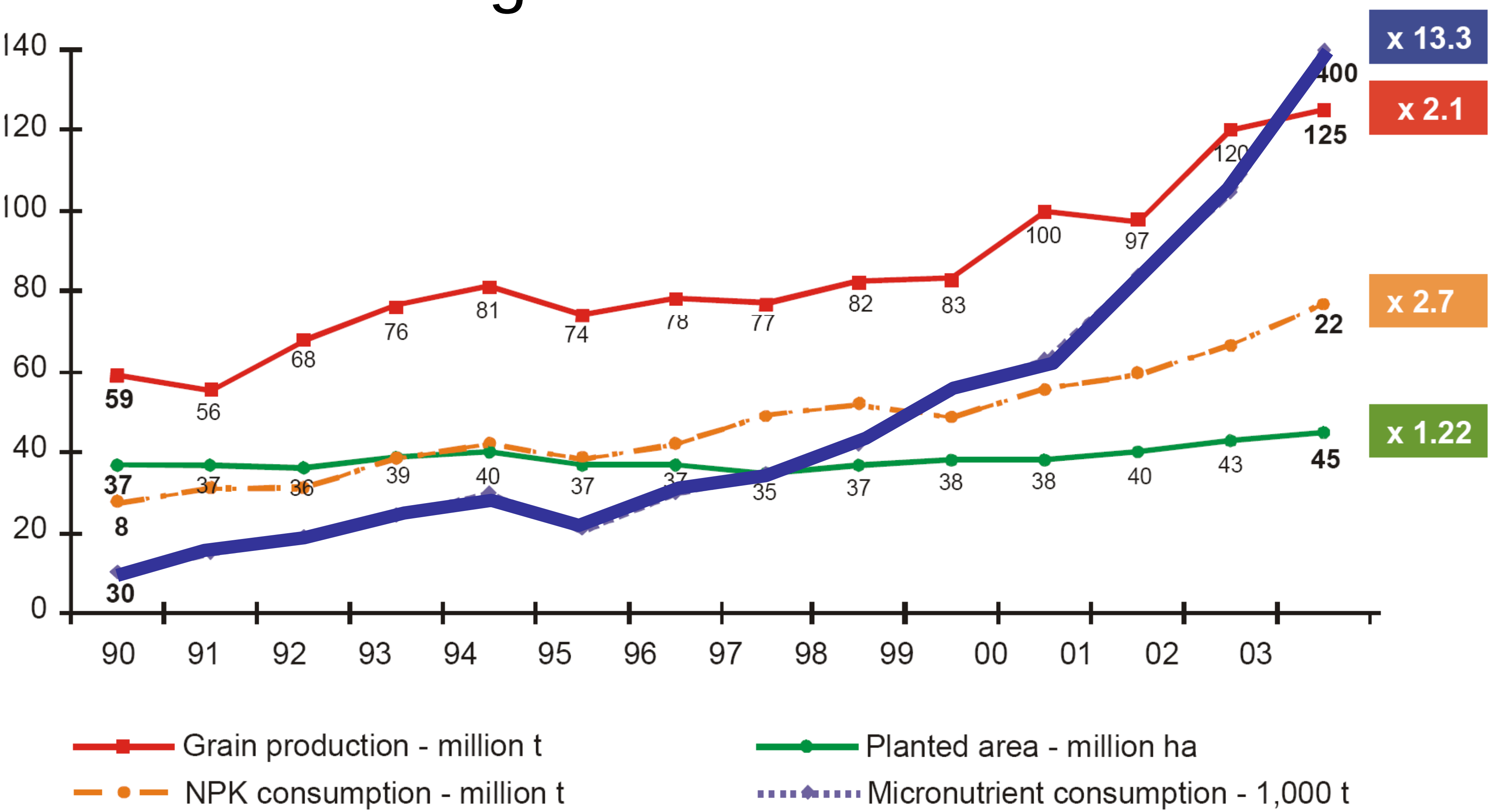
Table 3. Summary soil data for 21 countries and 1,635 samples (global region), five countries and 391 samples (temperate region), 16 countries and 1,244 samples (tropical region) to illustrate contrasts between soils in temperate and tropical regions[a]

Region	CEC	%OC	pH	B	Cu	Mn	Mo	Zn
Global	25.8	1.4	6.9	0.6	5.6	34.8	0.2	2.4
Temperate	28.1	2.2	6.6	0.7	5.7	28.3	0.3	2.6
Tropical	25.4	1.3	6.8	0.5	5.8	44.3	0.2	1.8

[a] Cation exchange capacity (CEC) expressed as meq/100 g soil; pH in water suspension and micronutrients as % mg L^{-1}. OC = organic carbon. Data from Sillanpaa [29] for soils under wheat or maize.

UFLA UNIVERSIDADE FEDERAL DE LAVRAS

Evolução de produção, área plantada e consumo de nutrientes (NPK e micro) na agricultura Brasileira



Fonte: Yamada (2004)

Balanço de micronutrientes na agricultura brasileira em 2008/2009 – 18 culturas (61.798.631 ha)

	B	Cu	Fe	Mn	Zn
	- - - - - - - - - -	- - - - - - - - - -	- - - - - - - - - -	- - - - - - - - - -	- - - - - - - - - -
Exportação das culturas (saídas)	2.762	2.764	20.634	9.607	6.770
Deduções das exportações	-	-	-	-	-
Exportação líquida de nutrientes (I)	2.762	2.764	20.634	9.607	6.770
Total de entradas[(3)] (II)	9.217	4.619	205.371	16.140	18.058
Balanço de nutrientes (II – I)	6.455	1.855	184.737	6.533	11.288
Índice de aproveitamento médio (I/II x 100)	30,0%	59,8%	10,0%	59,5%	37,5%
Fator de consumo (II/I)	3,3	1,7	10,0	1,7	2,7

Fonte: Cunha et al. (2010)

UFLA UNIVERSIDADE FEDERAL DE LAVRAS

Interações importantes: K

Plant Soil (2010) 335:155–180
DOI 10.1007/s11104-010-0520-1

Recent findings that micronutrient demand (Zn, B, Cu) can also be particularly high during the early reproductive growth (Kirkby and Römheld 2004) means that the transport of these nutrients into storage tissues also depends closely on the K (and Mg) status of source leaves.

Volker Römheld • Ernest A. Kirkby

The functions of these mineral nutrients in plant metabolism justifies their use in nutrient cocktails in mitigating frost resistance both on scientific grounds and in accord with field observations as discussed above.

Received: 1 Ap

However, much is still to be learned as for example the interrelationships between the micronutrients and K to enable adequate recommendations to farmers. Basic as well as applied research is urgently needed in this area.

Abstract Thi[...] research on potassium (K) in agriculture. Current basic knowledge of K in soils and plant physiology and nutrition is discussed which is followed by sections dealing specifically with future needs for basic and applied research on K in soils, plants, crop nutrition and human and animal nutrition. The section [...] plant stress situations in which K either acts alone or in combination with specific micronutrients. The emerging role of K in a number of biotic and abiotic stress situations is discussed including those of diseases and pests, frost, heat/drought, and salinity. Breeding crops which are highly efficient in upt

Interação entre Zn e N em trigo afeta Zn foliar

New Phytologist

Research

Improved nitrogen nutrition enhances root uptake, root-to-shoot translocation and remobilization of zinc (^{65}Zn) in wheat

Emin Bulent Erenoglu[1]*, Umit Baris Kutman[2]*, Yasemin Ceylan[2], Bahar Yildiz[2] and Ismail Cakmak[2]

[1]Department of Soil Science and Plant Nutrition, Cukurova University, 01330 Adana, Turkey; [2]Faculty of Engineering and Natural Sciences, Sabanci

- The results demonstrate that the N-nutritional status of wheat affects major steps in the route of Zn from the growth medium to the grain, including its uptake, xylem transport and remobilization via phloem. Thus, N is a critical player in the uptake and accumulation of Zn in plants, which deserves special attention in bio-fortification of food crops with Zn.

New Phytologist (2010)
doi: 10.1111/j.1469-8137.2010.03488.x

Key words: biofortification, nitrogen nutrition, phloem transport, wheat, zinc.

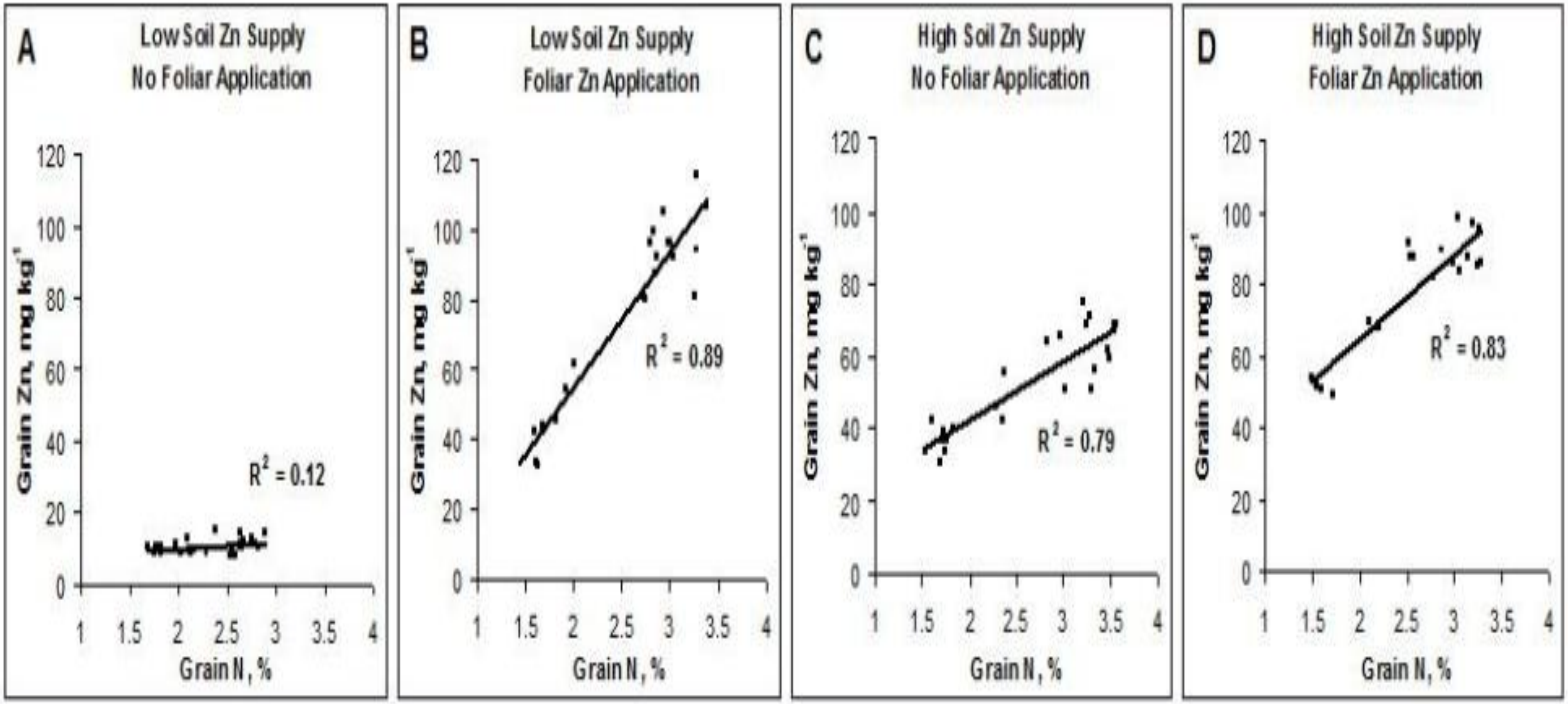
• When N supply was increased, the ^{65}Zn uptake by roots was enhanced by up to threefold and the ^{65}Zn translocation from roots to shoots increased by up to eight-fold, while plant growth was affected to a much smaller degree. Retranslocation of ^{65}Zn from old into young leaves and from flag leaves to grains also showed marked positive responses to increasing N supply.
• The results demonstrate that the N-nutritional status of wheat affects major steps in the route of Zn from the growth medium to the grain, including its uptake, xylem transport and remobilization via phloem. Thus, N is a critical player in the uptake and accumulation of Zn in plants, which deserves special attention in bio-fortification of food crops with Zn.

UNIVERSIDADE FEDERAL DE LAVRAS

Correlação entre Zn e N no grão (trigo)

(A e B = baixo Zn no solo; C e D = alto Zn no solo)

(A e C = sem Zn foliar; B e D = com Zn foliar)



Fonte: Kutman UB, Yildiz B, Ozturk L, Cakmak I (2010) Biofortification of durum wheat with zinc through soil and foliar applications of nitrogen. Cereal Chemistry 87, 1-9.

Uso de micronutrientes: a recomendação agronômica e as exceções

Dose *vs* Variabiliadade Ambiental (solos) e Genética

UNIVERSIDADE FEDERAL DE LAVRAS

Deficiência?

Como diagnosticar? Como corrigir?

Integrar tudo isso e mais alguma coisa...

...histórico da área

... fatores que afetam a disponibilidade

Aná

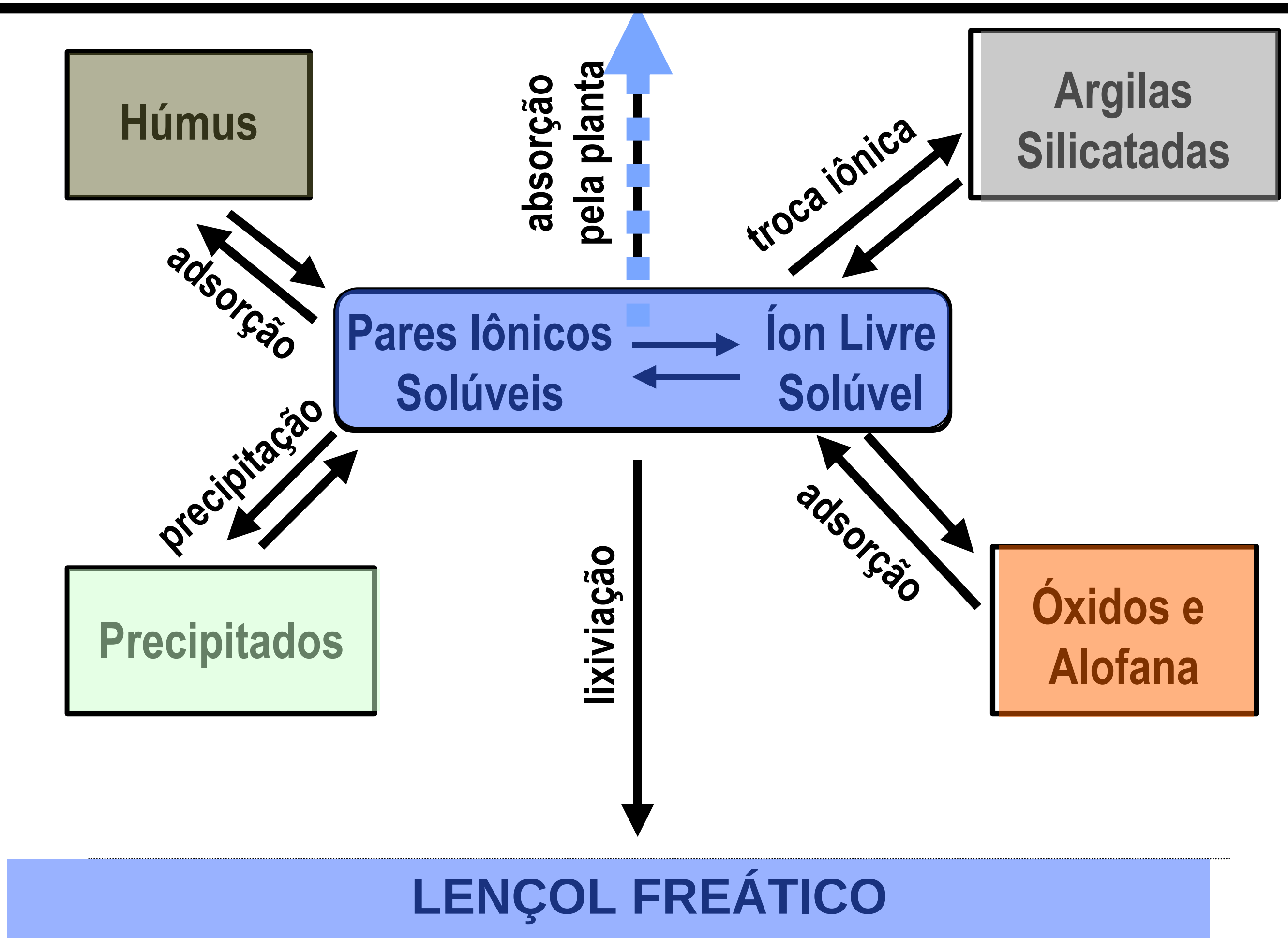
sual?

Análise foliar?

Vejam só com quem a planta tem que competir...

Quem ganha a disputa? A planta ou o solo?

A interação determina qual a melhor maneira **(método)** de adubar e qual adubo **(fonte)** é mais eficiente!



Limites para interpretação de micronutrientes na análise de solos (e.g., Cerrados)

Teor	B	Cu	Mn	Zn
	(água quente)	-------------Mehlich 1------------		
	----------------------mg/dm³---------------------			
Níveis críticos soja (Fundação MT – Relatório 2005)				
	0,5	*0,8*	*-*	*2,5*
Alto	> 0,5	> 0,8	> 5,0	> 1,6

Fonte: Galrão (2002).

Micro no solo: nível crítico *vs* nível ótimo

Turk J Agric For
32 (2008) 215-220

The Effect of Micronutrients in Ensuring Efficient Use of Macronutrients

Mohammad Jafar MALAKOUTI*

Soil Science Department, Tarbiat Modares University, P.O. Box 14115-111. Tehran - IRAN

Received: 29.01.2008

Abstract: Micronutrient deficiency is widespread in many Asian countries due to the calcareous nature of soils, high pH, low organic matter, salt stress, continuous drought, high bicarbonate content in irrigation water, and imbalanced application of fertilizers. Some of the adverse effects of micronutrient deficiency-induced stress in plants include low crop yield and quality, imperfect plant morphological structure (such as fewer xylem vessels of small size), widespread infestation of various diseases and pests, low

In consideration of the important role micronutrients have in promoting and maintaining human health, more research is needed to determine the advantages of using the optimum level of micronutrients instead of their critical level as an indicator with regard to yield, quality, and enrichment objectives for the future.

Key Words: Micronutrient deficiencies, calcareous soils, bicarbonate in water, crop yield and quality, crop enrichment, health promotion

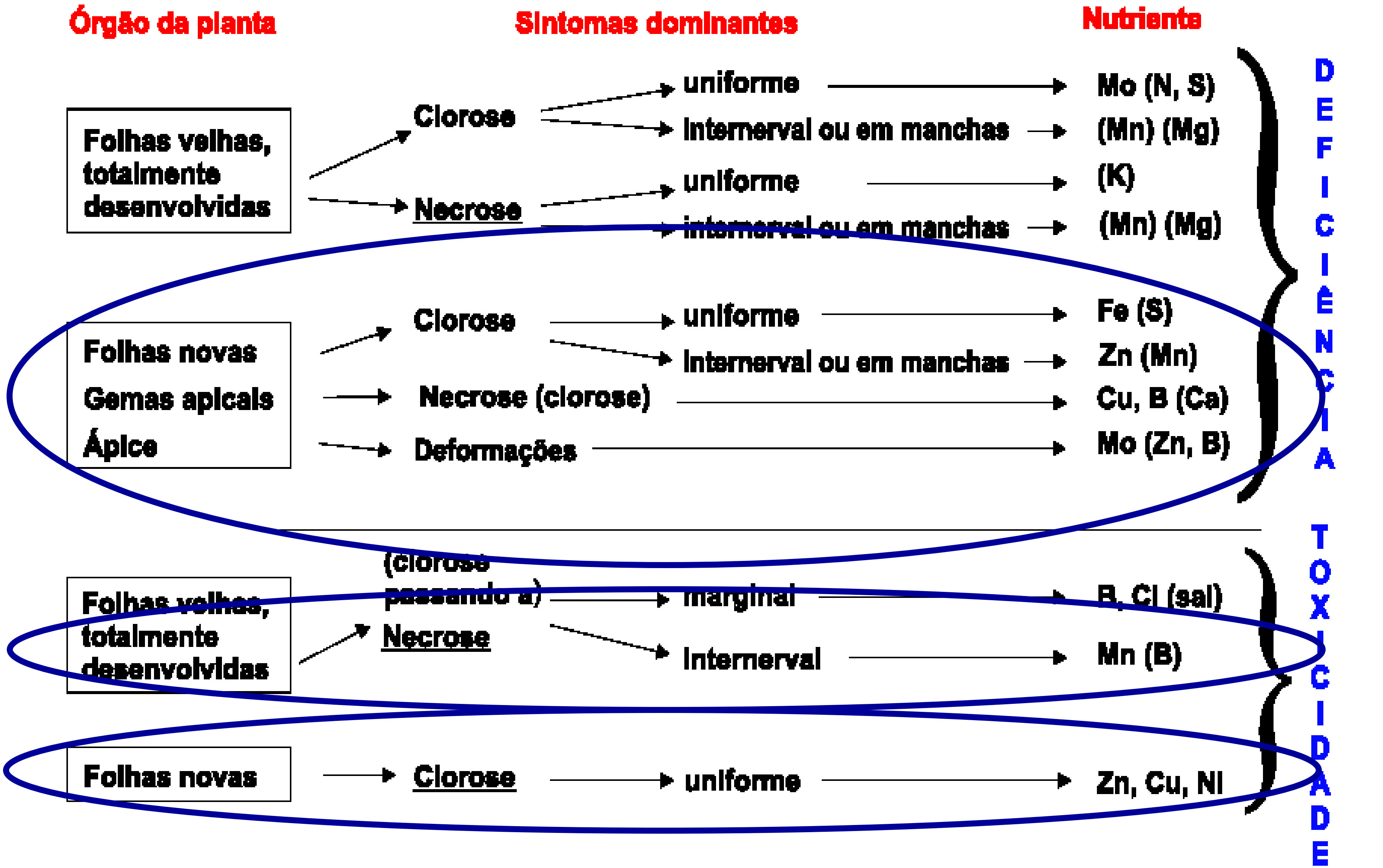
Concentrações de micronutrientes (mg/kg) consideradas adequadas para interpretação de análise foliar para algumas culturas na região dos cerrados

Cultura	B	Cu	Fe	Mn	Mo	Zn
Milho	*40-100*	*8-20*	*50-250*	*50-350*	*1-2*	*20-60*
Algodão	*10-25*	*6-20*	*30-250*	*20-200*	*0.1-0.2*	*15-100*
Silva et al. (1995)	*30-50*	*5-25*	*40-250*	*25-300*		*25-60*

Fonte: Diversas, compiladas por Yamada (2004).
(www.fertilizer.org/ifa/publicat/PDF/2004_ag_new_delhi_yamada.pdf)
(www.elsitioagricola.com/articulos/yamada/T.Yamada-Micronutrientes.pdf)

UFLA
UNIVERSIDADE FEDERAL DE LAVRAS

Chave simplificada de diagnose visual



Fonte: Römheld (2003), citado por Yamada (2004)

Potencial genético *vs* Teor no grão

Cultivares domésticas (D) e selvagens (W)

Annals of Botany **105**: 1211–1220, 2010
doi:10.1093/aob/mcq024, available online at www.aob.oxfordjournals.org

ANNALS OF BOTANY Founded 1887

PART OF A SPECIAL ISSUE ON PLANT NUTRITION

Genetic diversity for grain nutrients in wild emmer wheat: potential for wheat improvement

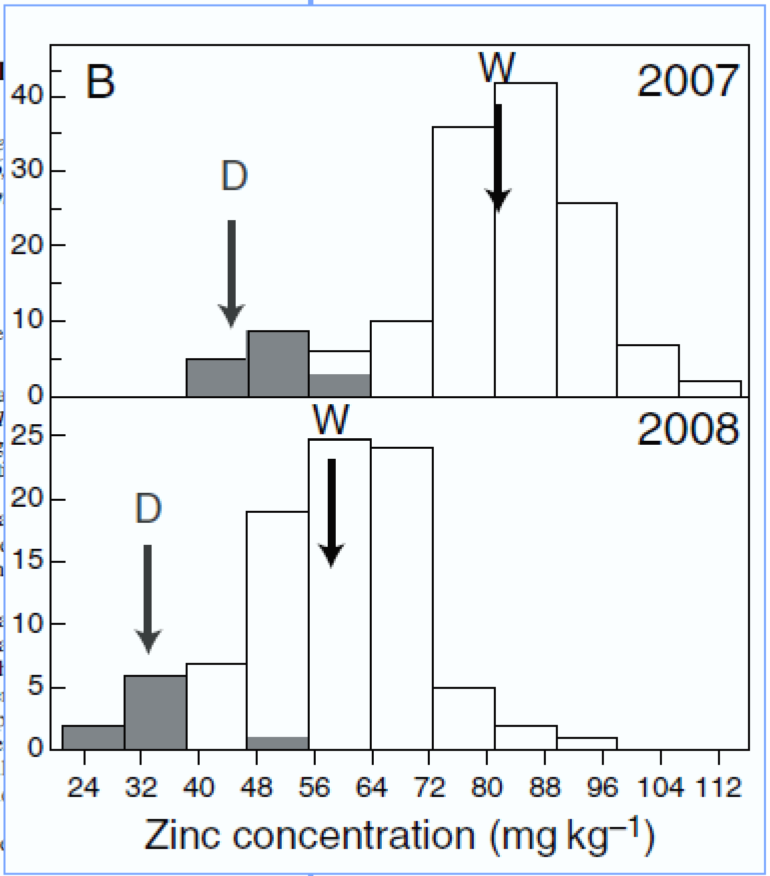
Merav Chatzav[1,†], Zvi Peleg[1,†], Levent Ozturk[2], Atilla Yazici[2], Tzion Fahima[3], I Yehoshua Saranga[1,*]

[1]*The Robert H. Smith Institute of Plant Science and Genetics in Agriculture, The Hebrew Unive 76100, Israel,* [2]*Faculty of Engineering and Natural Sciences, Sabanci University, Istanbul 34956, Evolutionary and Environmental Biology, The Institute of Evolution, Faculty of Science ar University of Haifa, Haifa 31905, Israel*
** For correspondence. E-mail saranga@agri.huji.ac.il*
[†]*These authors contributed equally to this work.*

Received: 6 October 2009 Returned for revision: 9 November 2009 Accepted: 1 December 2009 Published e

• *Background and Aims* Micronutrient malnutrition, particularly zinc and iron deficiency, a billion people worldwide due to low dietary intake. In the current study, wild emmer wheat (T ssp. *dicoccoides*), the progenitor of domesticated wheat, was tested for (1) genetic diversity in g centrations, (2) associations among grain nutrients and their relationships with plant product association of grain nutrients with the eco-geographical origin of wild emmer accessions.
• *Methods* A total of 154 genotypes, including wild emmer accessions from across the Nea Crescent and diverse wheat cultivars, were characterized in this 2-year field study for grain prot (zinc, iron, copper and manganese) and macronutrient (calcium, magnesium, potassium, phosph concentrations.
• *Key Results* Wide genetic diversity was found among the wild emmer accessions for all gra concentrations of grain zinc, iron and protein in wild accessions were about two-fold greater tha cated genotypes. Concentrations of these compounds were positively correlated with one anoth association with plant productivity, suggesting that all three nutrients can be improved concurre penalty. A subset of 12 populations revealed significant genetic variation between and within p minerals. Association between soil characteristics at the site of collection and grain nutrie showed negative associations between soil clay content and grain protein and between soi and grain zinc, the latter suggesting that the greatest potential for grain nutrient minerals li from micronutrient-deficient soils.
• *Conclusions* Wild emmer wheat germplasm offers unique opportunities to exploit favourabl nutrient properties that were excluded from the domesticated wheat gene pool.

Key words: grain quality, iron, macronutrient, micronutrient, protein, *Triticum turgidum* ssp. *dicoccoides*, wheat improvement, zinc.



Genótipos mais exigentes *vs* Adubação

Pak. J. Bot., 42(4): 2565-2578, 2010.

THE ROLE OF MICRONUTRIENTS IN CROP PRODUCTION AND HUMAN HEALTH

MUHAMMAD IMTIAZ[1*], ABDUL RASHID[2], PARVEZ KHAN, M.Y. MEMON AND M. ASLAM

[1]*Soil Science Division, Nuclear Institute of Agriculture, Tando Jam, Sindh, Pakistan*
[2]*Pakistan Atomic Energy Commission, HQ, Islamabad, Pakistan.*
[*]*Corresponding author E-mail: drimtiaz64@yahoo.com*

Abstract

The soils in Pakistan across 22 Mha cultivated area are predominantly alluvial and loessal, alkaline in pH, calcareous and low in organic matter. These factors are mainly responsible for nutrient fixation in soil and low availability to plants. Zinc (Zn) deficiency in Pakistan was the first micronutrient disorder recognised in early 1970s as a cause of *hadda* disease in rice. After identification of Zn deficiency, extensive research has been carried out during last four decades on micronutrient deficiencies in soils and their drastic effects on crops. Subsequently, field-scale
deficiencies
horticultura
deficient an
many other
nutritional
deciduous f
chickpea, c
deficiencies

The m
compounds
adult ranges
can cause s
hampering t
cereal based
contents of
agricultural
Food fortifi
and not easi
be a success
health. How
micronutrie
micronutrients containing fertilizers. Addition of such fertilizers will not only correct the deficiencies but also improve the fruit size and quality of crops. In general, 2-5 kg Zn ha^{-1} may be adequate for improved crop production, however, soil applied Fe is generally ineffective except for Fe-sequestrine. Repeated sprays of Ferrous sulphate ($FeSO_4$) or chelated Fe cure the chlorosis and improve the quality of food stuff. However, despite being highly cost effective, currently micronutrient use is negligible.

Maior teor nas partes comestíveis

⇩

Maior extração do solo

⇩

Maior necessidade de reposição

The development of micronutrient efficient genotypes can be a successive tool to overcome the micronutrient disorders in soil and for improvement in human health. However, the harvesting of micronutrient enriched grains from field would mine out more micronutrients. The cultivation of these genotypes can be integrated with the application of micronutrients containing fertilizers.

A procura da melhor fonte/método de aplicação

Existe “a melhor”?

UNIVERSIDADE FEDERAL DE LAVRAS

Fontes de micronutrientes

(Várias revisões: Lopes, 1984; Lopes, 1991; Volkweiss, 1991; Hignett & McClellan 1985; Mortvedt, 1991; Matens & Westermann, 1991; Mortvedt, 1999)

- Fontes inorgânicas
- Quelatos sintéticos
- Complexos orgânicos naturais
- “Fritas”

UFLA UNIVERSIDADE FEDERAL DE LAVRAS

Fontes de micronutrientes (cont.)

- **Subprodutos diversos:** industriais, urbanos *(e.g., lodo de esgoto)*, agrícolas, agroindustriais etc.

Atenção para aspectos legais da legislação brasileira

- INSTRUÇÃO NORMATIVA Nº 5, DE 23 DE FEVEREIRO DE 2007
  - Garantias e especificações dos fertilizantes minerais simples
- INSTRUÇÃO NORMATIVA Nº 25, DE 23 DE JULHO DE 2009
  - Garantias e especificações dos fertilizantes orgânicos
  - Agentes quelatantes e complexantes orgânicos autorizados para fertilizantes orgânicos e organominerais
- INSTRUÇÃO NORMATIVA Nº 27, DE 5 DE JUNHO DE 2006
  - Limites máximos de metais pesados tóxicos admitidos em fertilizantes

(vide **www.agricultura.gov.br**)

UFLA UNIVERSIDADE FEDERAL DE LAVRAS

Fertilizantes contendo micronutrientes com disponibilidade controlada

Fertilizer Research **38**: 213–221, 1994.

Needs for controlled-availability micronutrient fertilizers

J. J. Mortvedt
National Fertilizer and Environmental Research Center, Tennessee Valley Authority, Muscle Shoals, Alabama 35660, USA

Received 2 June 1993; accepted in revised form 18 February 1994

Key words: coated fertilizers, fritted products, slightly soluble sources

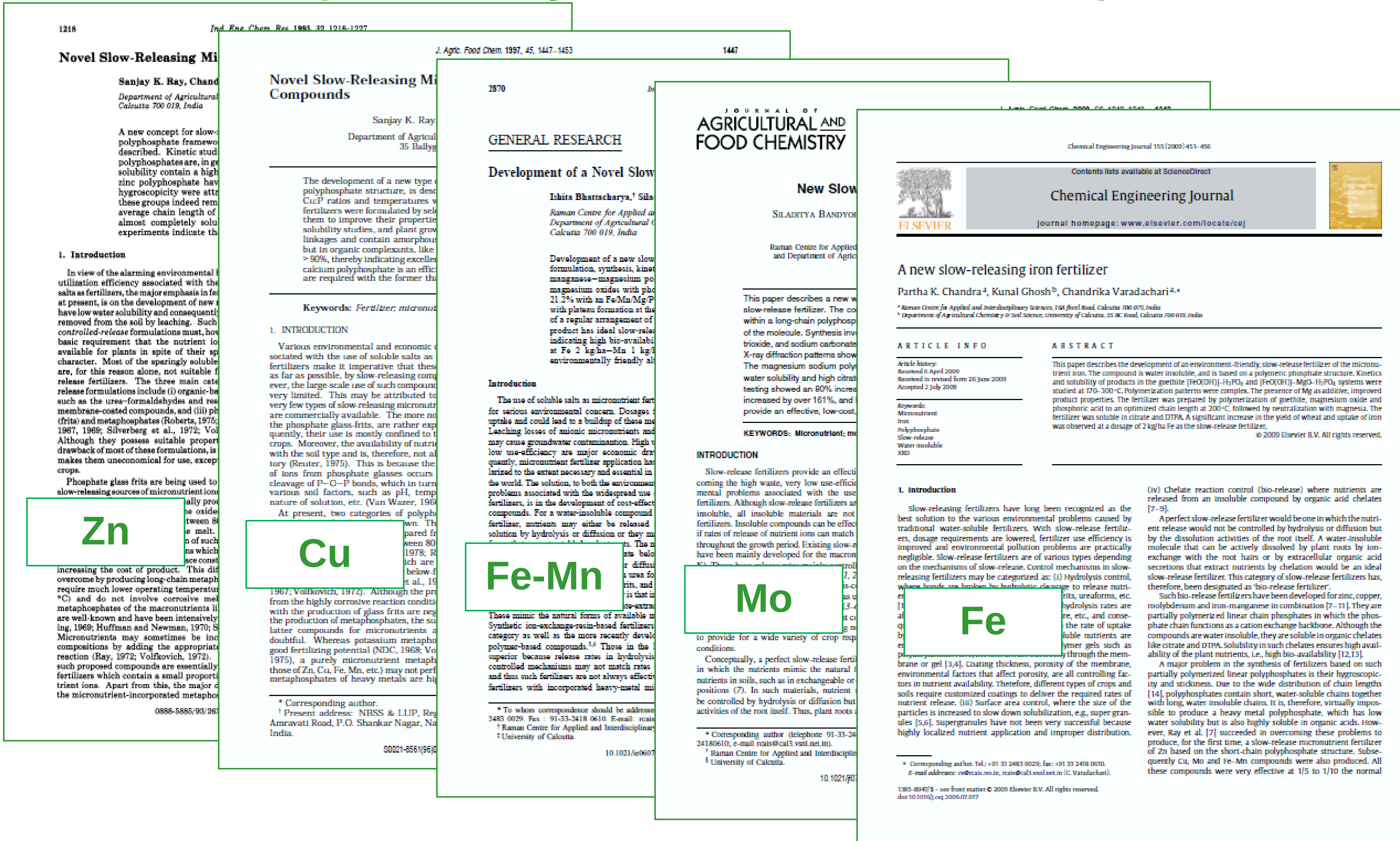
Abstract

Use of micronutrients for agronomic and horticultural crops has increased markedly in recent years. Increased use is related to higher nutrient demands from more intensive cropping practices and also from farming marginal lands. Most of the fertilizers used to correct micronutrient deficiencies are water- soluble inorganic sources or soluble organic products such as synthetic chelates or natural organic complexes. These fertilizers may react with soil to decrease their availability to plants. The rates of such chemical reactions may differ considerably with each micronutrient fertilizer and soil environment.

UNIVERSIDADE FEDERAL DE LAVRAS

“Novel Bio-Release Micronutrient Fertilizers”

(Publicações – 1993 a 2009)



UFLA
UNIVERSIDADE FEDERAL DE LAVRAS

Fertilizantes de Liberação Lenta

Mountain Research and Development (MRD)
An international, peer-reviewed open access journal
published by the International Mountain Society (IMS)
www.mrd-journal.org

MountainResearch
Systems knowledge

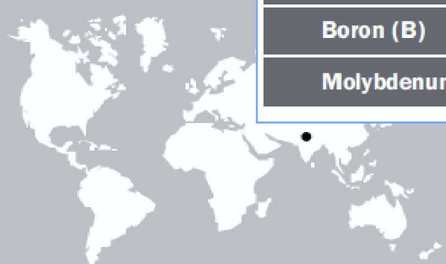
Biorelease Multinutrient Fertilizers for High-altitude Agriculture

Field Trials in t

Chandrika Varada
** Corresponding auth*
[1] Raman Centre for A
[2] Department of Agric

Open access article:

Biorelease micronutrients	Major chemical constituents (%)	Solubility (%)		
		Water	0.005 M DTPA	0.33 M citric acid
Zinc (Zn)	ZnO: 26.1, NH_4^+: 10.5, P_2O_5: 43.5	2.4	100	100
Copper (Cu)	CuO: 17.2, NH_4^+: 20.3, P_2O_5: 47.5	4.5	100	100
Iron-manganese (Fe-Mn)	Fe_2O_3: 5.4, MnO_2: 2.7, MgO: 18.4, P_2O_5: 34.5	0.2	90	95
Boron (B)	B_2O_3: 20.1, Na_2O: 12.6, MgO: 15.6, P_2O_5: 44.4	5.6	34.9	100
Molybdenum (Mo)	MoO_3: 4.5, Na_2O: 13.0, MgO: 12.9, P_2O_5: 45.6	6.6	100	100



*Himalaya. These were biorelease fertilizers of zinc, iron, manganese, copper, boron, and molybdenum synthesized in a laboratory. Trials were conducted at Pithoragarh (1240 m), Kumaon Himalaya, with radish (*Raphanus sativus*) followed by amaranthus (residual effect;* Amaranthus blitum*), and at Auli (2900 m), Garhwal Himalaya, with cabbage (*Brassica oleracea L. var. capitata*) and thereafter lahi (residual effect;* Brassica rugosa*).*

effect trial, lahi (a leafy vegetable) produced a remarkable 164% increase in yield that was statistically significant at a 1% level. Overall, the data suggest that biorelease fertilizers are very effective at low dosages. They would be particularly suitable for crop production in mountainous regions.

Keywords: *Biorelease; fertilizers; field trials; vegetables; multinutrients; altitude; Himalaya; India.*

Peer-reviewed: *December 2008* **Accepted:** *May 2009*

Subprodutos de mineração como fontes de micro

Plant Soil (2010) 326:425–435
DOI 10.1007/s11104-009-0023-0

REGULAR ARTICLE

Mineralization of copper, manganese and zinc from rock mineral flour and city waste compost for efficient use in organic farming

Yashbir Singh Shivay · Tore Krogstad · Bal Ram Singh

Received: 2 February 2009 / Accepted: 5 May 2009 / Published online: 16 May 2009

Abstract Restricted supply of micronutrients is a common constraint for plant growth worldwide, especially in organic farming systems where nutrients supply to crops mostly depends on the mineralization of native soil organic matter, decomposition of applied manures and crop residues. A laboratory incubation study was therefore conducted to investigate the potential release of copper (Cu), manganese (Mn) and zinc (Zn) from the rock mineral flour (RMF) and city waste compost (CWC) as compared to inorganic micronutrient fertilizers for 140 days. Release of the micronutrients from RMF and CWC showed different trends. The results showed that about 4.6% of Cu added as RMF was released irrespective of the quantity of the RMF applied. However, Cu release from CWC increased from 0.7 to 3.5% as the amount of compost added was increased. Copper recovery from copper sulphate was 98%. Manganese release from RMF decreased from 114 to 103% as the RMF level was increased, while the corresponding decrease in Mn release from CWC was from 14 to −3%. Manganese recovery from manganese sulphate was 100%. Zinc release from RMF increased from 5.8−15.5%, with an increase in the amount of RMF applied, while no Zn was released from CWC. Recovery of Zn from zinc sulphate was 98%. These results show that RMF and CWC could be used to meet Cu, Mn and Zn requirements of organically grown cereals. The results of the investigation have general applicability in organic farming.

Keywords Quartz · Rock mineral flour · City waste compost · Copper · Manganese · Zinc · Mineralization · Organic farming

Rochas moídas como fontes de micronutrientes

Anais da Academia Brasileira de Ciências (2006) 78(4): 715-720
(Annals of the Brazilian Academy of Sciences)
ISSN 0001-3765
www.scielo.br/aabc

Sustainable farming with native rocks: the transiti

WILLIAM S. FYFE[1], OTHON H. LEONARDOS[2] and SUZI I
[1]University of Western Ontario, Dept. Earth Sciences, London, Ontari
[2]Universidade de Brasília, Centro de Desenvolvimento Sus
SAS Quadra 05, Bloco H sala 200, 70070-914 Brasília, DF
[3]Universidade de Brasília, Centro de Estudos Avançados Multi
Núcleo de Estudos Agrários, Campus Darcy Ribeiro, Edifício Mult
1° Andar sala B1-50, 70910-900 Brasília, DF, Bras

Manuscript received on September 29, 2005; accepted for publication
contributed by WILLIAM S. FYFE* AND OTHON H. LEON

"Let the

ABSTRACT
The development process which humanity passed through favored a series of c
quality of life and longevity, however, it also provoked upsets and severe tra
and in the human food security. Such process is driving the ecosystems to b
the nutrients' supply, via nourishment. To change this panorama, the prese
incorporating the stonemeal technique as a strategic alternative to give back th
to the soils. This technology has the function of facilitating the rejuvenation
availability of the necessary nutrients to the full development of the plants
proliferation of life in all its dimensions.

Key words: stonemeal, remineralize, soil remediation, sustainable agricultu

INTRODUCTION

In the many parts of the globe, how many people suffer of bad nutrition? According to data of many research institutes, at least 1/5 of the world population starves. On the other hand, developed countries, like the United States and some European countries consume most of what is produced in the world and there is no world that could sustain that level of consumption for all unless we change the way we fertilize our soils. Another remarkable difference in the world that shows such inequalities among people

is the longevity ra
36.1 years, Ethiop
dian magazine *Th*
2004) listed the w
listed was food, th
ple. The second w
face water quality
ally, the Nobel Pea
Kenya, writes abo
soil erosion and th
It has been k
food quality is a c
sary to have a food
lowing the huge e

*Member Academia Brasileira de Ciências
Correspondence to: William S. Fyfe
E-mail: pjfyfe@uwo.ca

Anais da Academia Brasileira de Ciências (2006) 78(4): 721-730
(Annals of the Brazilian Academy of Sciences)
ISSN 0001-3765
www.scielo.br/aabc

The use of rocks to improve family ag

SUZI H. THEODORO[1] and OTHON H. LE
[1]Universidade de Brasília, Centro de Estudos Avançados Multidiscipl
Campus Darcy Ribeiro, Edifício Multiuso I, Bloco B, 1
70910-900 Brasília, DF, Brasil
[2]Universidade de Brasília, Centro de Desenvolvimento Sustentável, S
70070-914, Brasília, DF, Brasil

Manuscript received on September 29, 2005; accepted for publ
contributed by OTHON H. LEONARDO

ABSTRACT
During the second half of the 20th century, the introduction of new che
about a revolution in food production, but this has also cause deep
the natural environment. In developing tropical countries, record yiel
widespread deforestation and loss of topsoil. The *stonemeal* research d
practices as it is an environmental friendly and socially responsible
and conservation by means of the addition of natural rock powders
magnesium, potassium and micronutrients. The research adopted a
conducted among small farmers of a rural community located in th
major goal was to demonstrate that there is a harmless cheap and sin
or impoverished soils, which allow farmers to sustain high product
land. Results have confirmed the economic, environmental and prod
stonemeal technique for corn, rise, manioc, sugar cane and horticultur
chemical fertilizers. The fertilization of the soil with rocks, allows the
which maintain production levels while building a sustainable fertile

Key words: stonemeal, nutrients, small farmers.

INTRODUCTION

Many of the problems of tropical agriculture originate in the nature of soils. Tropical soils commonly have inherently low fertilities. They have been exposed to long periods of weathering, which results in highly depleted soils with low organic matter, low cation exchange capacities and overall low inherent fertility (van Straaten 2002). This kind of situation

which is co
to the low s
Brazil. Thi
due to influ
and cultural
further enha
litical local
productive s
grain crop,
of the count
ceptable em

*Member Academia Brasileira de Ciências
Correspondence to: Suzi Huff Theodoro
E-mail: suzitheodoro@unb.br

Anais da Academia Brasileira de Ciências (2006) 78(4): 731-747
(Annals of the Brazilian Academy of Sciences)
ISSN 0001-3765
www.scielo.br/aabc

Farming with rocks and minerals: challenges and opportunities

PETER VAN STRAATEN
Department of Land Resource Science, University of Guelph, Guelph, ON, Canada N1G 2W1

Manuscript received on September 29, 2005; accepted for publication on March 13, 2006;
presented by OTHON H. LEONARDOS

ABSTRACT
In many parts of the world food security is at risk. One of the biophysical root causes of falling per-capita food production is the declining quality and quantity of soils. To reverse this trend and increase soil fertility soil and plant nutrients have to be replenished. This review provides a literature survey of experiences of using multi-nutrient rock fertilizers for soil fertility enhancement from temperate and tropical environments. Advantages and limitations of the application of rock fertilizers are discussed. Examples are provided from two successful nutrient replenishment projects in Africa where locally available rock fertilizers are used on highly leached acid soils. The potential of combining organic materials alongside rock fertilizers in soil fertility replenishment strategies is stressed.

Key words: soil nutrient replenishment, rock fertilizer, phosphate rock.

INTRODUCTION

Food is essential for life. But despite major efforts to alleviate food shortage and outright hunger of millions of people, there are still approximately 800 million individuals who go to bed with empty stomachs every night. The need to feed approximately 9 to 10 billion people during the middle of the 21st century will put increasing pressure on land resources and it is obvious that the production of food will have to rise to keep pace with rising food demands. The per capita food production is still declining in some parts of the world, for example in Sub-Saharan Africa.

One of the biophysical root causes of falling per capita food production is the declining quality and quantity of the land resource base, in particular the soil (Sanchez et al. 1997, Sanchez 2002). Soils, the foundation for survival and food security, are increasingly over-exploited in some parts of the world. In order to reverse this trend of land and soil degradation it is necessary to either expand the land base under cultivation or to intensify crop production per unit of land. But even if the land base is extended, most of the additional land that would be brought into cultivation is of lower quality and at risk for soil degradation. Clearly, the declining soil quantity and quality in large parts of the developing world poses a threat to food security.

Some land has inherently low fertility because of the soils overly 'infertile' rock formations. Other land is made less fertile due to human intervention, such as the extraction of nutrients through harvesting and other 'exports' without replenishing the extracted soil nutrients. In some parts of Africa the soils are degraded, eroded and successively 'mined' of their nutrients (Sanchez et al. 1997, Sanchez 2002). The average annual depletion rate of nutrients is 22 kg of nitrogen (N), 2.5 kg of phos-

E-mail: pvanstra@uoguelph.ca

Métodos de aplicação

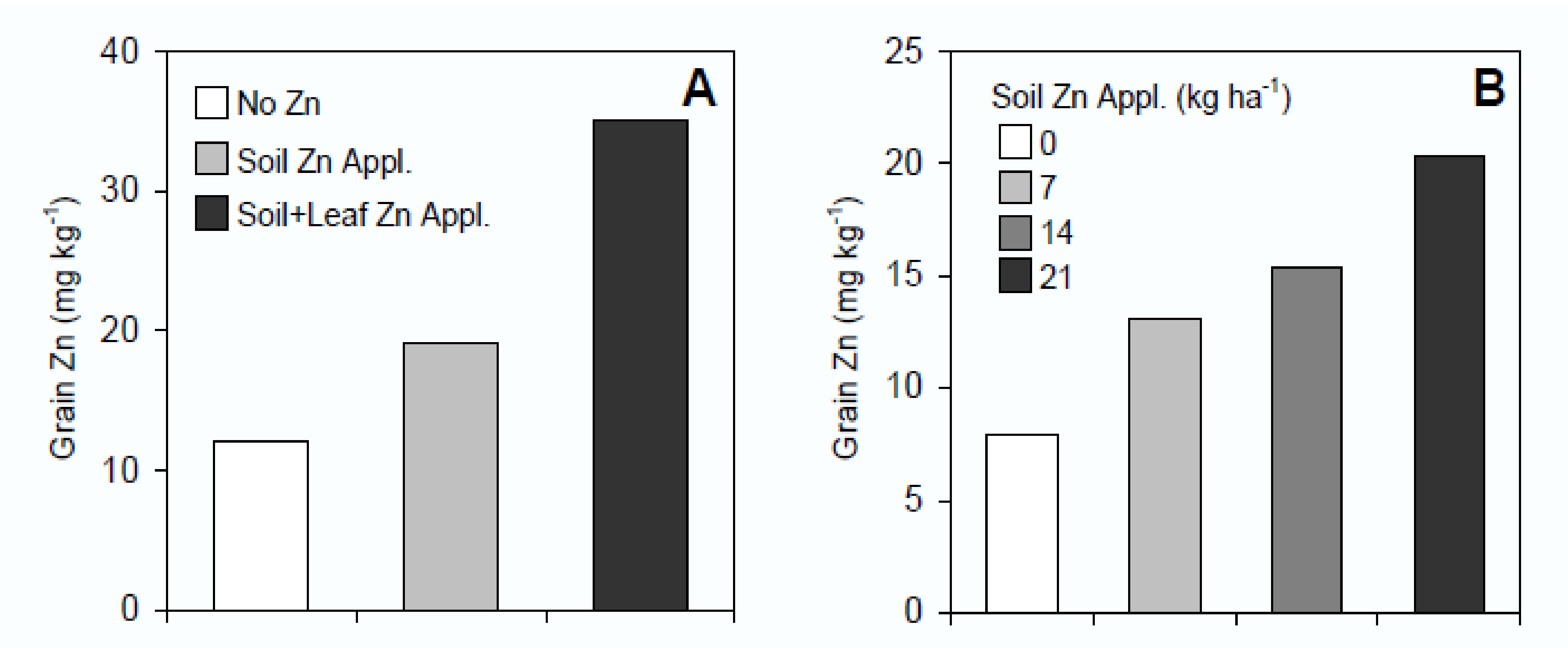
- Aplicações via solo
- Adubação foliar
- Tratamento de sementes
- Aplicação em raízes de mudas

Concentração de Zn no grão

(trigo em solo calcário deficiente de Zn)

A = adubação via solo e foliar com sulfato de Zn

B = doses crescentes de Zn no solo



Fonte: Cakmak I, Pfeiffer WH, McClafferty B (2010) Biofortification of durum wheat with zinc and iron. Cereal Chemistry 87, 10-20.

Zn foliar aplicado no enchimento de grãos

9092 *J. Agric. Food Chem.* **2010,** *58,* 9092–9102
DOI:10.1021/jf101197h

JOURNAL OF AGRICULTURAL AND FOOD CHEMISTRY
ARTICLE

Biofortification and Localization of Zinc in Wheat Grain

I. CAKMAK,*[,†] M. KALAYCI,[‡] Y. KAYA,[§] A. A. TORUN,[∥] N. AYDIN,[⊥] Y. WANG,[#] Z. ARISOY,[§] H. ERDEM,[∥] A. YAZICI,[†] O. GOKMEN,[†] L. OZTURK,[†] AND W. J. HORST[#]

To our knowledge, this is the first study to show that the timing of foliar Zn application is of great importance in increasing grain Zn in wheat, especially in the endosperm part that is the predominant grain fraction consumed in many countries. Providing a large pool of Zn in vegetative tissues during the grain filling (e.g., via foliar Zn spray) is an important practice to increase grain Zn and contribute to human nutrition.

and grain fractions (e.g., bran, embryo and endosperm) in 3 locations. Foliar application of $ZnSO_4$ was realized at different growth stages (e.g., stem elongation, boot, milk, dough stages) to study the effect of timing of foliar Zn application on grain Zn concentration. The rate of foliar Zn application at each growth stage was 4 kg of $ZnSO_4 \cdot 7H_2O$ ha^{-1}. Laser ablation (LA)-ICP-MS was used to follow the localization of Zn within grain. Soil Zn application at a rate of 50 kg of $ZnSO_4 \cdot 7H_2O$ ha^{-1} was effective in increasing grain Zn concentration in the Zn-deficient location, but not in the locations without soil Zn deficiency. In all locations, foliar application of Zn significantly increased Zn concentration in whole grain and in each grain fraction, particularly in the case of high soil N fertilization. In Zn-deficient

UFLA UNIVERSIDADE FEDERAL DE LAVRAS

Quantidade (teor)

=

Qualidade (aproveitamento)?

Pesquisas em bioacessibilidade

Biofortificação na China: foco em bioacessibilidade

Environ Geochem Health (2007) 29:413–428
DOI 10.1007/s10653-007-9086-0

ORIGINAL PAPER

Improving human micronutrient biofortification in the soil–plant as a case study

Xiao-E. Yang · Wen-Rong Chen · Ying Feng

Received: 7 February 2006 / Accepted: 2 February 2007 / Publ

Abstract Micronutrient malnutrition is a major health problem in China. According to a national nutritional survey, approximately 24% of all Chinese children suffer from a serious deficiency of iron (Fe) (anemia), while over 50% show a sub-clinical level of zinc (Zn) deficiency. More than 374 million people in China suffer from goiter disease, which is related to iodine (I) deficiency, and approximately 20% of the Chinese population are affected by selenium (Se) deficiency. Micronutrient malnutrition in humans is derived from deficiencies of these elements in soils and foods. In China, approximately 40% of the total land area is deficient in Fe and Zn. Keshan and Kaschin-Beck diseases always appear in regions where the soil content of Se in low. The soil–plant system is instrumental to human nutrition and forms the basis of the "food chain" in

malnutrition · Plant nutritional strategies

Soil-plant system strategies that have been adopted to improve human micronutrient nutrition mainly include:

(1) **exploiting micronutrient-dense crop genotypes** by studying the physiology and genetics of micronutrient flow from soils to the edible parts of crops;

(2) **improving micronutrient bioavailability** through a better knowledge of the mechanisms of the enhancers' production and accumulation in edible parts and its regulation through soil-plant system;

(3) improving our knowledge of the **relationship between the content and bioavailability** of micronutrients in soils and those in edible crop products for better human nutrition;

(4) **developing special micronutrient fertilizers and integrated nutrient management** technologies for increasing both the **density of the micronutrients in the edible parts** of plants and their **bioavailability to humans**.

Considerações finais

"Food is a need; lack of food is visible.

Nutrition is a want; lack o nutrition is invisible"

(Meeera Shekar, World Bank)

– Problemas alimentares são visíveis, enquanto que problemas de desnutrição não o são

"No Ministry of Agriculture thinks about Health.

No Ministry of Health thinks about Agriculture"

(Meeera Shekar, World Bank)

– Agricultura deve ser pensada do ponto de vista de Saúde Pública
  – Saúde Pública deve ser pensada do ponto de vista Agrícola

- A **agricultura** precisa ser pensada do **ponto de vista nutricional** e os **micronutrientes são essenciais** neste sentido
  – "Nutrition should shape Agriculture" (Embaixador Willian J. Gaverlink)

UFLA UNIVERSIDADE FEDERAL DE LAVRAS

Luiz Roberto Guimarães Guilherme, Ph.D. (guilherm@dcs.ufla.br)
Universidade Federal de Lavras - Departamento de Ciência do Solo