Effect of Micronutrients in Ensuring Efficient Use of Macronutrients

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Our soils are faced with micronutrients deficiencies mainly due to:

- **High pH,**
- **High $CaCO_3$,**
- **Low organic matter,**
- **High bicarbonates in the irrigation water,**
- **Over use of P-fertilizers,**
- **High temperature,**
- **Continuous drought, Salinity and**
- ***most important item is the absence of micronutrient-fertilizers in the farmers' conventional fertilization practices.***

Table 1– Percentage of $CaCO_3$, O.C., and available zinc in some orchards in different regions of Iran*.

Region	pH	O. C. (%)	$CaCO_3$ (%)	Zinc (mg/kg)
Damavand	7.9	0.80	20	0.70
Uromieh	7.8	1.20	10	0.80
Maragheh	8.0	0.53	14	0.75
Semirom	7.9	1.15	45	0.50
Mashad	7.8	1.00	30	0.60

*The average amounts of HCO^-_3 in irrigation water is about 4.0 meq/li in the studied regions.

High Bicarbonate in the irrigation Water

نگارندگان :
محمد جعفر ملکوتی
مریم علی‌احیایی
ژاله خوش‌طبر

پاییز ۱۳۷۸

نشریه فنی شماره ۶۷

RC_5 RC_4 RC_3 RC_2 RC_1

For example, if our irrigation water has 4 meq/li (244 mg/l) of HCO_3^-, and if it is added to a field crop or an orchard at a rate of 5000 m^3 per year, then the yearly amount of added HCO_3^- to soil will exceed *one tone* (1220 kg/ha).

The above-mentioned factors slow down the rate of absorption and movement of micronutrients within vascular tissues. Therefore, the movement of micronutrients to the leaf, seed and fruit is greatly impeded, resulting in very low concentrations in plant parts consumed by animals and humans. Consequently, due to the calcareous nature of soils animals and humans confront severe deficiencies of micronutrients.

• **Let us see why higher pH and higher bicarbonate in the plant rhizosphere reduce micronutrient availability?**

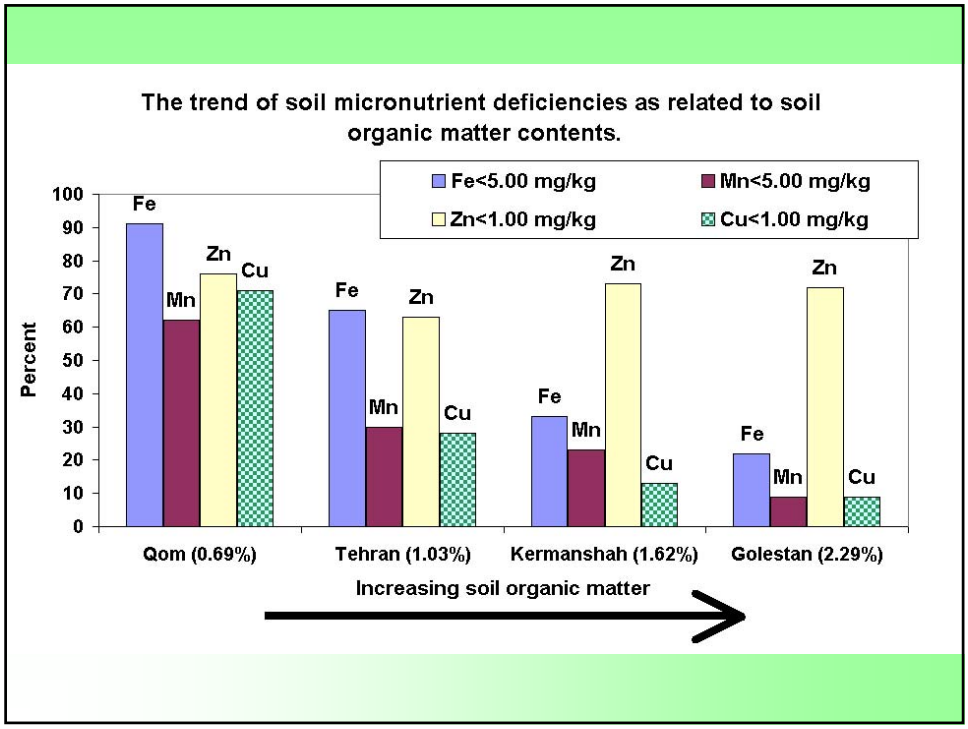
$CaCO_3 + H_2O \rightleftharpoons HCO^-_3 + Ca^{++} + OH^-$

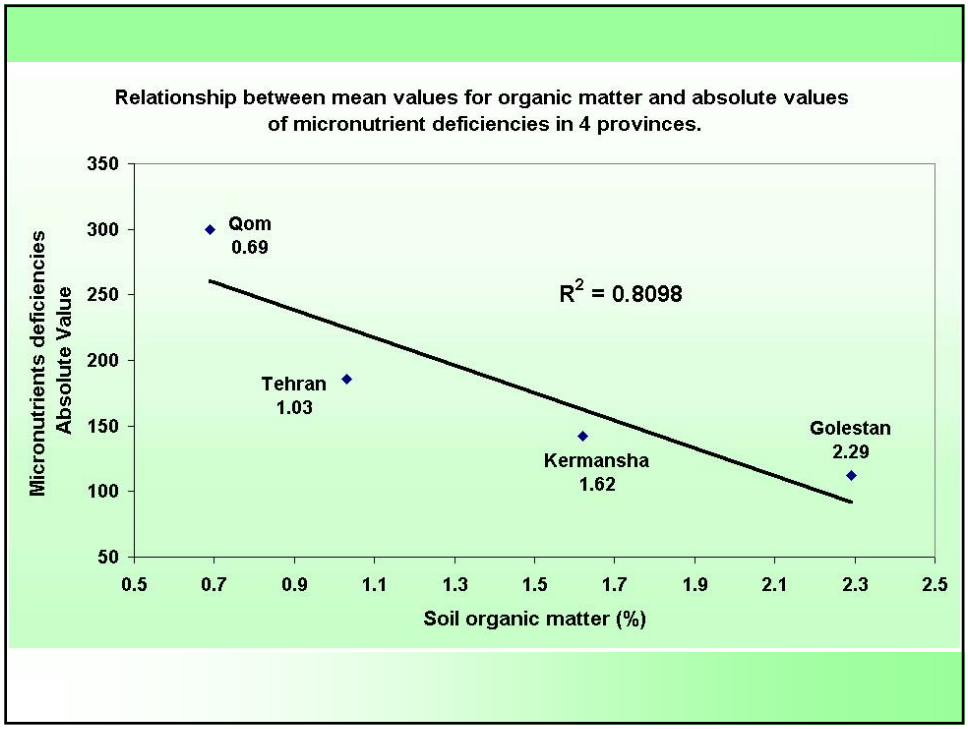
$CaCO_3 + H_2O + CO_2 \rightleftharpoons 2HCO^-_3 + Ca^{++}$

$CaCO_3 + 2H^+ \rightleftharpoons 2HCO^-_3$

$HCO^-_3 \rightleftharpoons CO^{\uparrow}_2 + OH^-$

$2OH^- + M^{++} \rightleftharpoons M(OH)_2\downarrow$; where M^{++} is a micronutrient.


The trend of soil micronutrient deficiencies as related to soil organic matter contents.
Fe<5.00 mg/kg
Mn<5.00 mg/kg
Zn<1.00 mg/kg
Cu<1.00 mg/kg
Percent
100
90
80
70
60
50
40
30
20
10
0
Fe
Mn
Zn
Cu
Qom (0.69%)
Tehran (1.03%)
Kermanshah (1.62%)
Golestan (2.29%)
Increasing soil organic matter


Relationship between mean values for organic matter and absolute values of micronutrient deficiencies in 4 provinces.
Micronutrients deficiencies Absolute Value
350
300
250
200
150
100
50
Qom
0.69
Tehran
1.03
Kermansha
1.62
Golestan
2.29
R2 = 0.8098
0.5
0.7
0.9
1.1
1.3
1.5
1.7
1.9
2.1
2.3
2.5
Soil organic matter (%)

The signs of zinc deficiency in apple tree, calf and human (Malakouti, 2003).

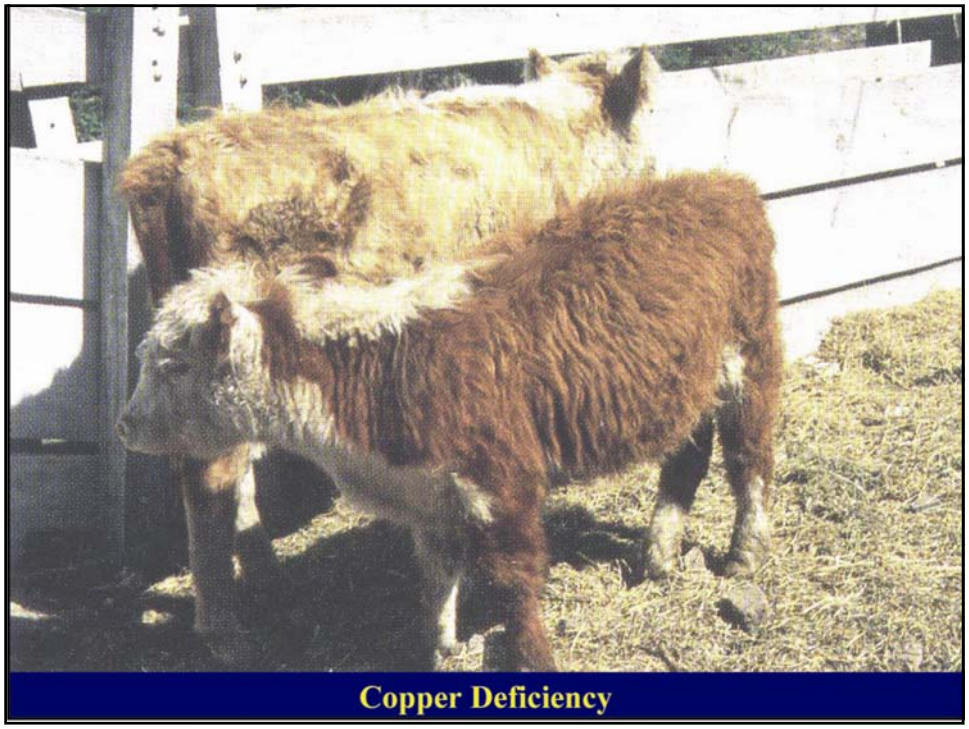
The signs of iron deficiency in apple leaves, calf (Fe and Cu) and human (Malakouti and Tehrani, 2005).

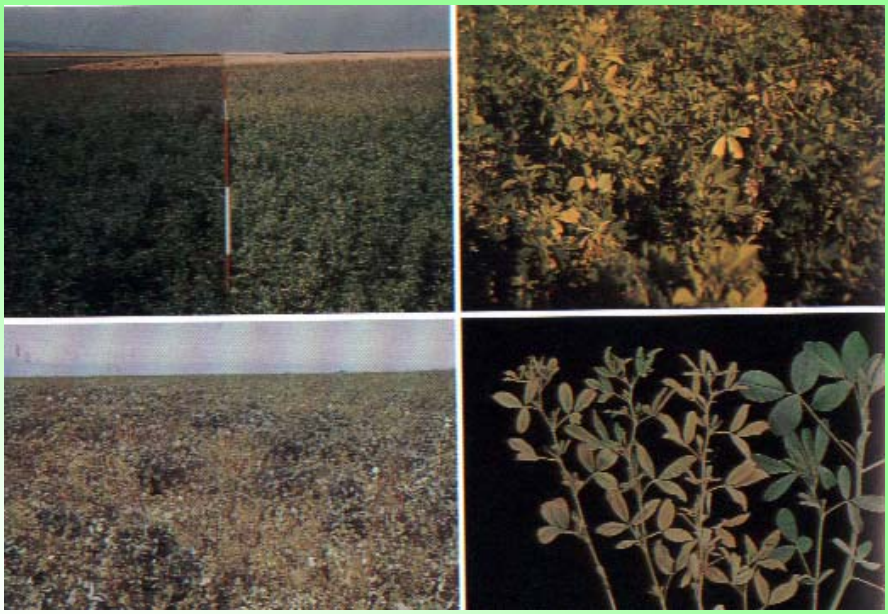
Mn deficiency in wheat **(Bergmann, 1997)**

Boron deficiency in wheat
(Snowball & Robson, 1991; Bennet, 1993)

Cu deficiency in wheat

(Snowball & Robson, 1991; Bennet, 1993; Bergmann, 1997)





Mo deficiency in alfalfa (Bergmann, 1997)

What will happen when we are faced with micronutrients deficiencies?

According to the Liebig's (1863) ***Law of the Minimum*****, these deficiencies will slow down plant growth and reduce crop yield and quality.**

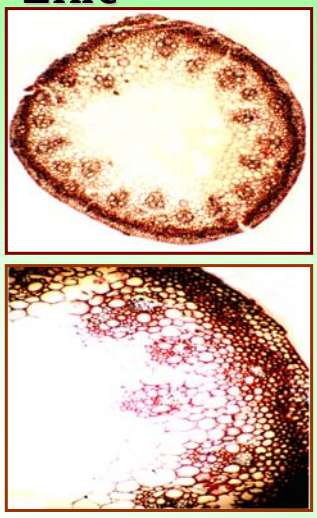
Some of the adverse effects that will develop when plants are stressed with micronutrients deficiencies include (Welch *et al.*, 1991; Rengel and Graham, 1995; Malakouti and Homaee, 1995; Marschner, 1995; Cakmak *et al.*, 1997; Malakouti and Tehrani, 1997; Graham *et al.*, 2000; Welch, 2003; Alloway, 2004; Cakmak, 2005):

- **Yield decrease;**
- **Lower crop quality;**
- **Imperfect morphological structure;**
- **Increased bio and non-bio-stresses;**
- **Widespread infestation of various diseases and pests;**
- **Low activation of phytosidrophores and zincosidrophores and**
- **Lower fertilizer use efficiencies**

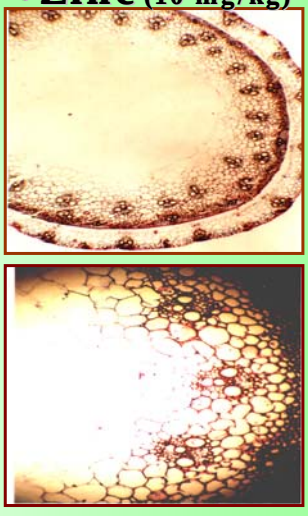
- **In addition, micronutrients deficiencies *induce structural changes* in plant (root, stem, and leaf)**

so that, often, fewer xylem vessels with smaller size would be noticed in stressed plants (Gadallah and Ramadan, 1977; Keshavarz *et al.*, 2005)

+ Salinity (100m moles/liter)
- Zinc



+ Salinity (100m moles/liter)
+Zinc (10 mg/kg)



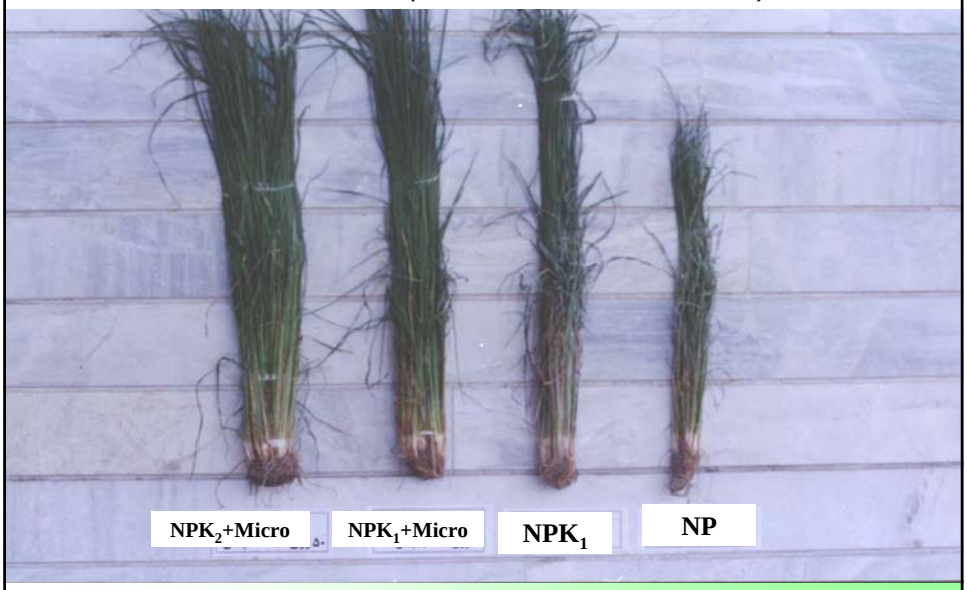
Take-all disease due to imbalanced fertilization in wheat root (Malakouti, 2000)

By supplying plants with micronutrients either through soil application, foliar spray, or seed treatment, we will be able to increase the yield and improve the quality of our crops as well as promote macro-fertilizer use efficiency.

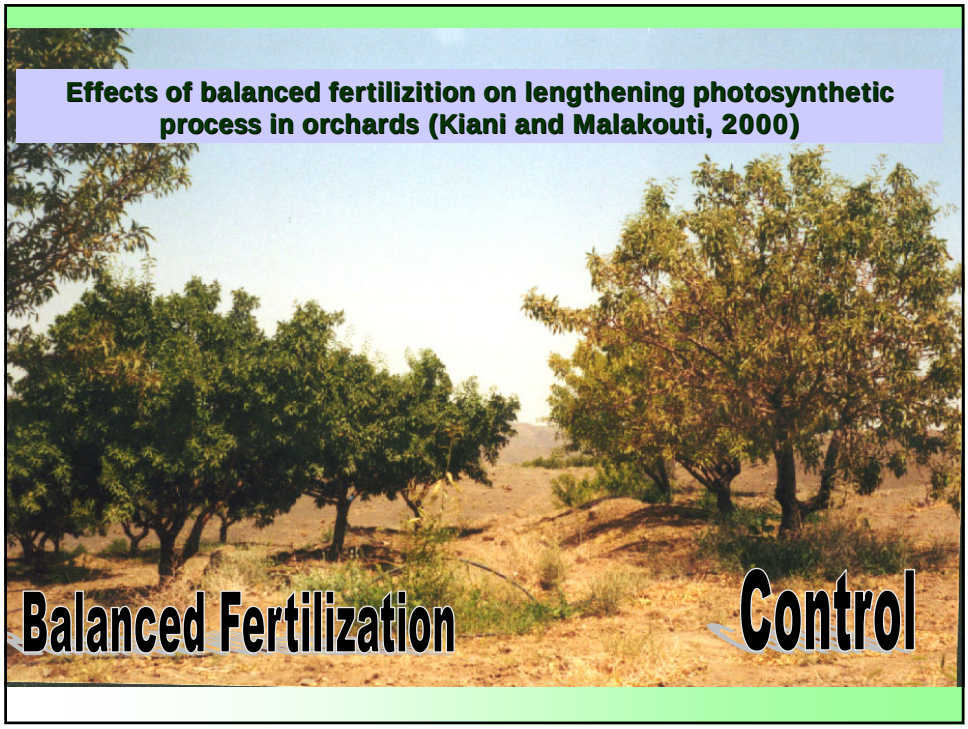
NPK+Micro **NPK** **NP**

Effects of micronutrient application on producing vigour grain *(Malakouti, 2000)*

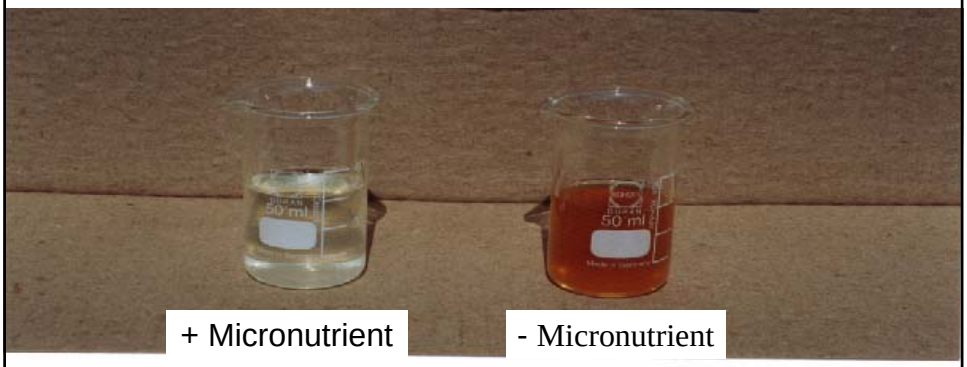
Effects of balanced fertilization in ensuring efficient use of micronutrients *(Malakouti and Kavousi, 2004)*



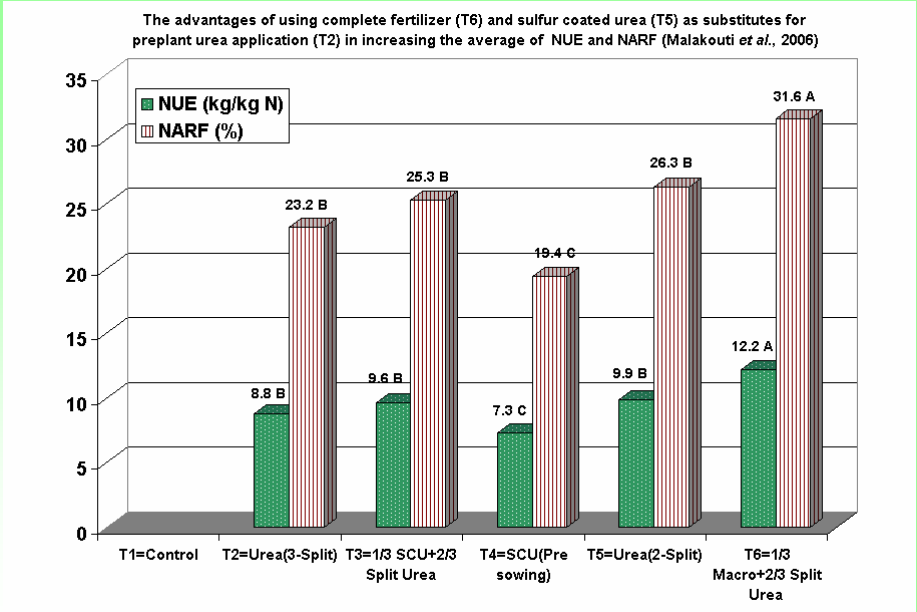
Effects of micronutrient application on the premature of canola *(*Salimpour *et al., 2001)*



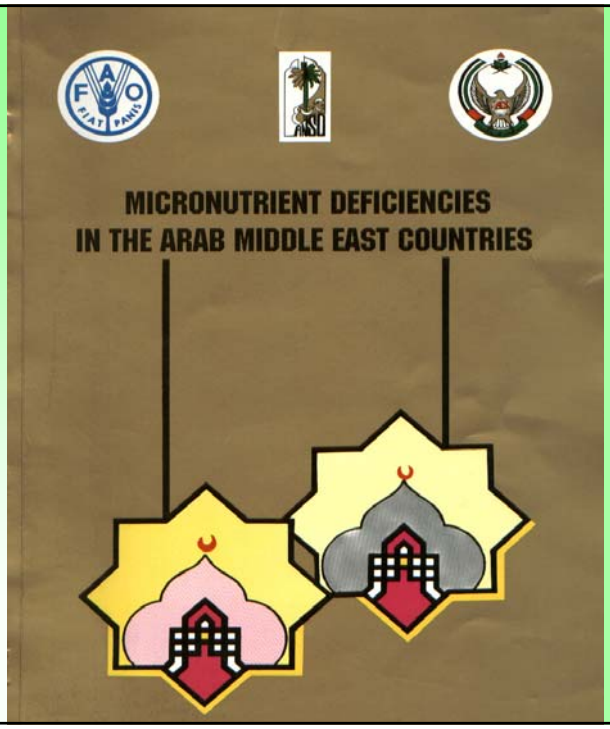
Effects of micronutrient application on the discoloration of the apple juice due to formation of antioxidants *(Souri and Malakouti, 2000)*

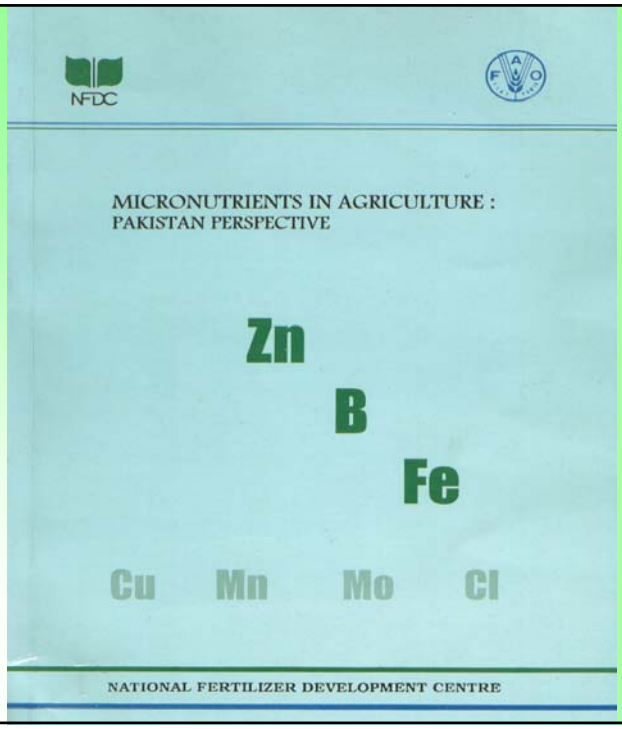


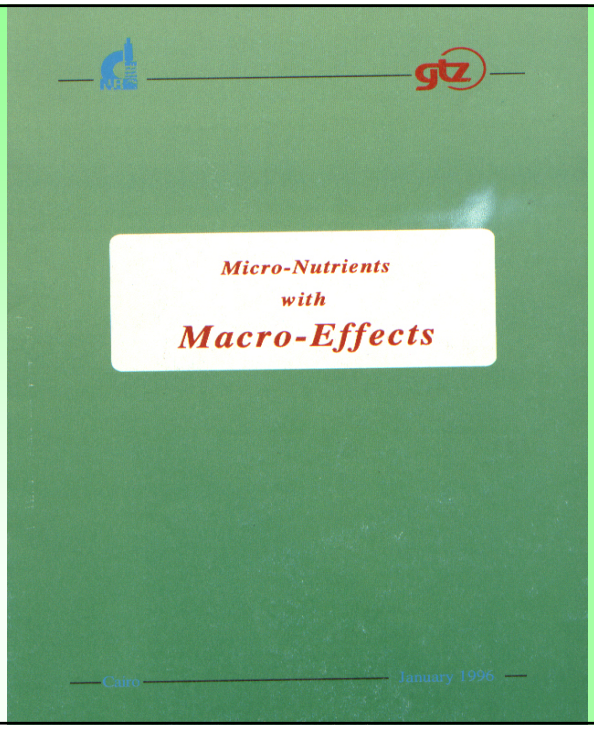
Effects of micronutrient application on the discoloration of the apple juice due to formation of antioxidants ***(Souri and Malakouti, 2000)***

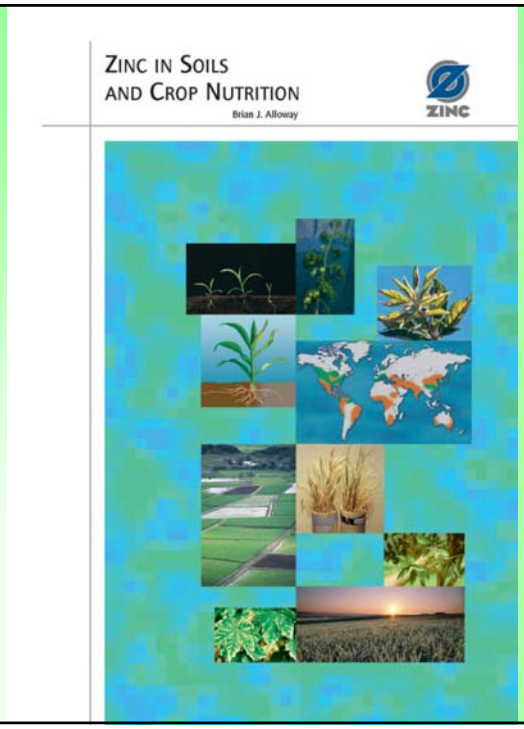


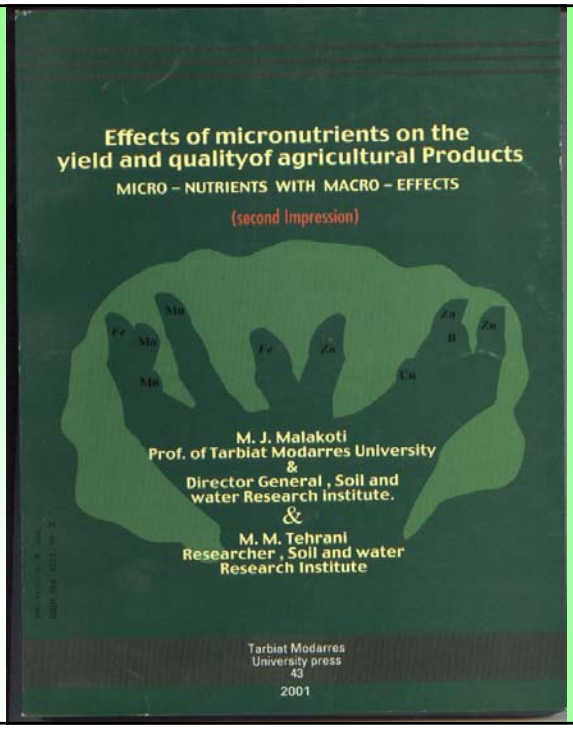
Research results of the last decade on the calcareous soils of Iran show that at the present time among micronutrients, zinc deficiency is the most important detriment to effective crop yields. Other important micronutrients that increase crop yield and quality are in the following order (Malakouti *et al.*, 1999): Zn>Fe>B>Mn>Cu>Mo.




NFDC
MICRONUTRIENTS IN AGRICULTURE :
PAKISTAN PERSPECTIVE
Zn
B
Fe
Cu
Mn
Mo
Cl
NATIONAL FERTILIZER DEVELOPMENT CENTRE


gtz
Micro-Nutrients
with
Macro-Effects
Cairo
January 1996


ZINC IN SOILS
AND CROP NUTRITION
Brian J. Alloway
ZINC


Effects of micronutrients on the
yield and qualityof agricultural Products
MICRO – NUTRIENTS WITH MACRO – EFFECTS
(second Impression)
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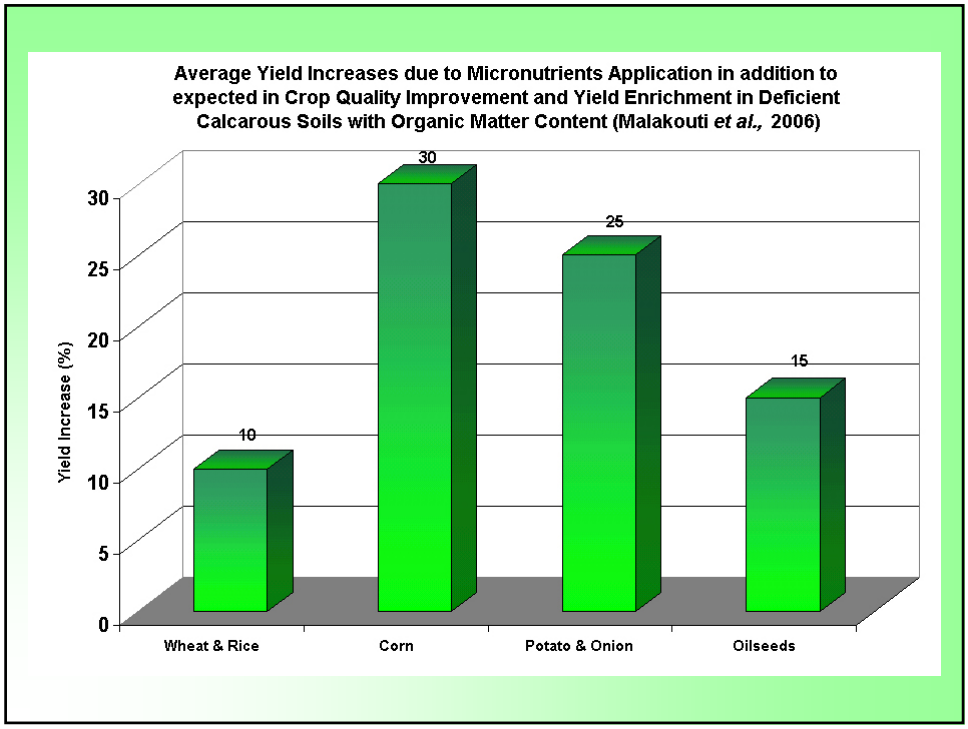
Tarbiat Modarres
University press
43
2001

- **It means we have a big gap between Research, Education and Extension in transferring the valuable data to the farmers and in changing their habits of conventional fertilization methods.**
- **Despite a great deal of data that proves the importance of balanced fertilization, more than 80% of fertilizers used by farmers consist only of N & P-fertilizers.**

- **Finally, in the case of calcareous soils, the conventional idea (belief) that micronutrients increase crops yield by 10-20% is an understatement. In fact, in some cases, specially with non-efficient cultivars such as Durum wheat (*Triticum aestivum* L.), micronutrients can more than double the grain yield.**


Average Yield Increases due to Micronutrients Application in addition to expected in Crop Quality Improvement and Yield Enrichment in Deficient Calcarous Soils with Organic Matter Content (Malakouti *et al.*, 2006)
Yield Increase (%)
0
5
10
15
20
25
30
10
30
25
15
Wheat & Rice
Corn
Potato & Onion
Oilseeds


Healthy Society
میهن خویش را کنیم آباد

Balanced Fertilization (+zinc) | Unbalanced Fertilization

THANK YOU

Acknowledgment

Finally, I would like to express my deep sense of appreciation and thank to all the researchers and staff members of the Soil and Water Research Institute, as well as all those graduate students of Soil Sciences Department of Tarbiat Modarres University who have made valuable contributions to this presentation.