Application of micronutrients: pros and cons of different application strategies

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Application techniques of micronutrients

1) Micronutrients – considering best management practices
2) Methods of micronutrient application
    - Soil application
    - Fertigation
    - Foliar application
    - Pros and cons of foliar *vs*. soil
3) Summary

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Micronutrients – considering best management practices

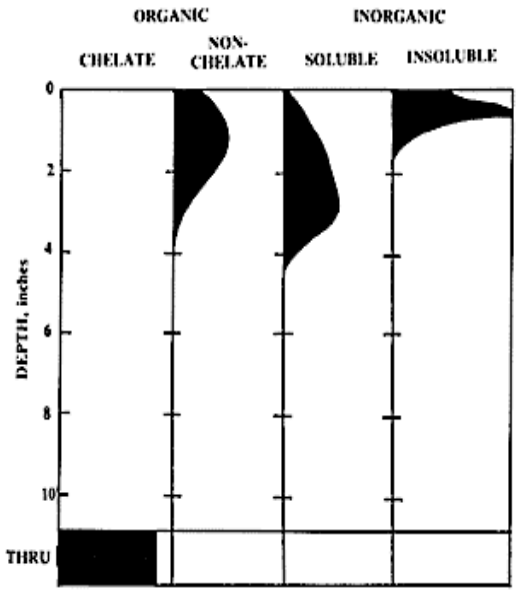
- foliar and soil analysis (application may aggravate plant performance)
- building soil fertility
  - tillage
  - drainage
  - water supply
  - pH-adjustment,…
- rootstock / variety selection
- plant density
- organic and mineral fertiliser management

Soil application - general

- more appropriate for perennial crops (main root zone in deeper soil layers)
- amounts to be applied are much higher compared to foliar app.
- different formulations with different mobility
- band application reduces required amounts by >50%
- orchards/perennial crops:
  - deep injection into the soil
  - *implantation of micronutrient capsules into the trunk*
- micronutrient enrichment of the soil as a strategy?

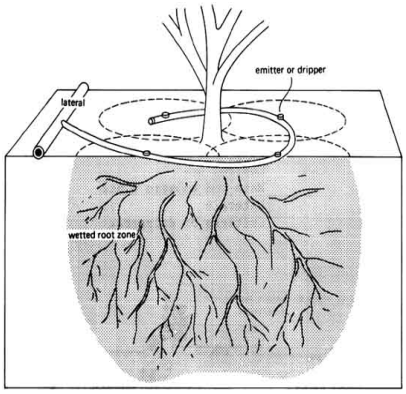
Rates of Mn fertiliser (as $MnSO_4$) required for optimal yield of soybean grown on Mn deficient soils (source: Marschner, 1995)

Mode of Mn Fertilizer application	requirement for optimal yield (kg Mn ha^{-1})
broadcast	14
banded	3
foliar sprays (2x)	0.1



Distribution of Zn added to the top of soil in columns of Thurman loamy sand after leaching with 500 mm water (Dickey 1982)

Fertigation: development of a „sweet zone“



e.g. in calcareous soils

… use of highly acidic fertilisers

• drop of soil pH
  - increased availability of soil nutrients
  - anti-clogging of pipes and emitters
  - reduced interference of bicarbonates

Foliar application - general

- uptake mechanisms of nutrients by roots and leaves - some significant differences:
  - uptake by roots directly stimulated by light
  - no direct or opposite effect with foliar uptake
  - quantity of uptake restricted
  - decline with plant age
  - climatic limitations (scorch; use of surfactants)
  - can be highly effective
  - more rapid, more even and more temporary effects (→ repeated applications)

Pros and cons of foliar *vs.* soil

Cons:

- limited nutrient concentrations due to leaf burn risk
  - high differences between species and varieties!
- low penetration rates
- rapid drying of spray solution
- washing off by rain
- nutrient leaching from leaves
- limited rates of translocation

Pros and cons of foliar *vs.* soil

Pros:

- technical: high compatibility
- soil related limitations of nutrient uptake
  - Zn and Mn uptake in calcareous soils
  - lime induced Fe chlorosis
  - high performance chelates for different soil pH

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Effects of spraying Fe-EDDHA or diluted H_2SO_4 for curing Fe chlorosis on chlorophyll concentration and pod yield of *Pisum sativum* L. (Mengel and Kirkby 2001)

Treatment	chlorophyll (mg g^{-1} fresh wt)	pod yield (t ha^{-1})
control	1.37	1.79
H_2SO_4	1.83	3.36
Fe-EDDHA	1.78	3.15

Pros and cons of foliar *vs.* soil

Pros *(contd.)*:

- nutrient interaction
  - Fe/Mn antagonism
  - indirect Mo/N synergism

    and uptake antagonism SO_4^{2-}/MoO_4^{2-}

Fe deficiency induced Mn toxicity in flax (*Linum usitatissimum* L.) grown in a calcareous soil of pH 8.0 (Moraghan 1979)

		contents in shoot dry weight		
Treatment	shoot dry wt. (g per pot)	Mn (mg kg^{-1})	Fe (mg kg^{-1})	P (%)
control (-Fe)	3.60	881	83	0.32
2 mg Fe per pot (Fe EDDHA)	5.55	64	174	0.32

Effect of soil or foliar application of Mo on dry matter yield, N-uptake and Mo content in groundnut grown on a low Mo, acid sandy soil (Rebafka 1993)

			Mo content (µg g^{-1} dry wt)		
Mo application (g ha^{-1})	dry matter (kg ha^{-1})	N uptake (kg ha^{-1})	shoots	nodules	seeds
0	2685	70	0.02	0.4	0.02
200 (soil)	3413	90	0.02	1.5	0.20
200 (foliar)	3737	101	0.05	3.7	0.53

Pros and cons of foliar *vs.* soil

Pros *(contd.)*:

- semiarid regions: method of choice, where irrigation systems are missing
- multi-functional effects of foliar sprays

Effects of soil and foliar application of Cu ($CuSO_4$ 5 H_2O) on growth parameters and grain yield of wheat (source: Marschner 1995)

Treatment	ears m^{-2}	grains/ ear	grain yield (g dry wt m^{-2})
no application	37.0	0.14	0.03
soil application			
2.5 kg ha^{-1}	28.8	2.3	1.0
10.0 kg ha^{-1}	58.5	2.9	2.3
foliar application (2%, 2 kg ha^{-1})			
1x: stem elongation	63.8	17.1	14.0
2x: stem elong. and booting	127.4	52.7	79.7

Effect of Cu fertilisation on stem melanosis (*Pseudomonas cichorii*) in wheat grown on a Cu deficient soil (Mahli et al. 1989)

Treatment	Cu fertiliser (kg Cu ha^{-1})	% disease	grain yield (kg ha^{-1})
nil	0	92	294
$CuSO_4$ banded	10	76	511
$CuSO_4$ incorporated	10	34	2016
$CuSO_4$ foliar spray	10	6	2116
Cu Chel, foliar spray	2	7	2505

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Pros and cons of foliar *vs.* soil

Pros *(contd.):*

- supporting critical crop growth stages
- fruit trees / perennial crops and multicropping systems
- highly productive open field and protected cropping systems

Summary

method of application	
soil	**foliar**
deep rooting (perennial) crops, fruit orchards, plantation crops	highly intensive production systems; flexibility (emergency; multi-cropping systems,...), rapid and temporary effects, supporting critical crop growth stages,…
application of granules, powder, solutions in high amounts	minor amounts applied at one time, repeated applications
Fe often more efficiently applied via soil	benefits where site/soil conditions limit nutrient uptake via soil (interactions between nutrients, dry conditions,...)
inherent chemical characteristics of carriers determine mobility and uptake	

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Micronutrient sources

Type	Stability	Chemical	Key facts
Chelated	Strong	EDTA DTPA EDDHA	Stable at high pH and with phosphates Crop safe
Sequestered	Moderate	Phenolics Lignosulphonates	Poor for soil application but OK for foliar application
Complexed	Weak	Amino acids, Citrates, Glucoheptonates etc	Poor stability but cheap
Inorganics	None	Sulphates Nitrates Carbonates	Soil application ineffective. High rates needed Risk of phytotoxicity

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Relationship between Mo content of soybean seeds and subsequent seed yield, grown on Mo deficient soil
(Marschner 1995)

Mo content of seeds (mg kg^{-1} dry wt)	seed yield (kg ha^{-1})
0.05	1505
19.0	2332
48.4	2755

Effects of B fertilization on yield, seed B content, seed viability and germination of Black Gram (*Vigna mungo* L.)
(source: Marschner 1995)

Treatment	seed yield (g dry wt per plant)	B content (mg kg^{-1} seed)	% of seedlings		
			normal	weak	non viable
-B	5.0	3.4	57	40	3
+B	5.1	7.4	92	6	2