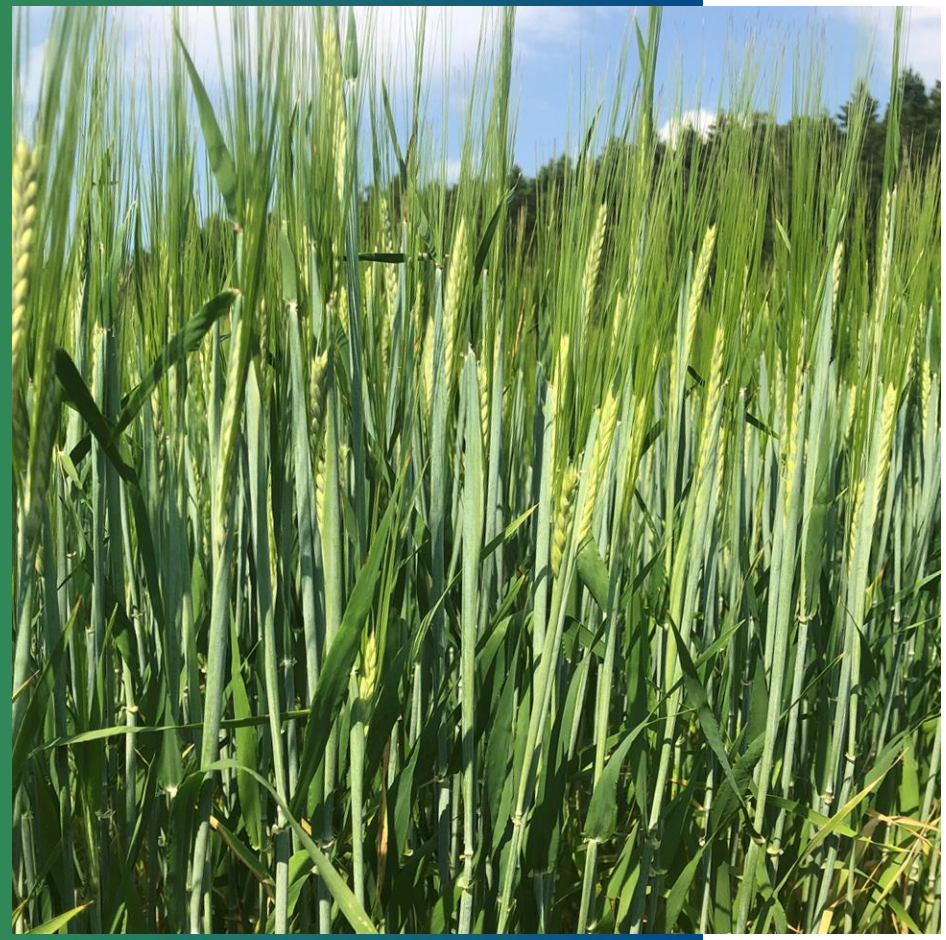

PRO AGRO LECTORIUM

Plant nutrition: micronutrients

Vladimir Nosov

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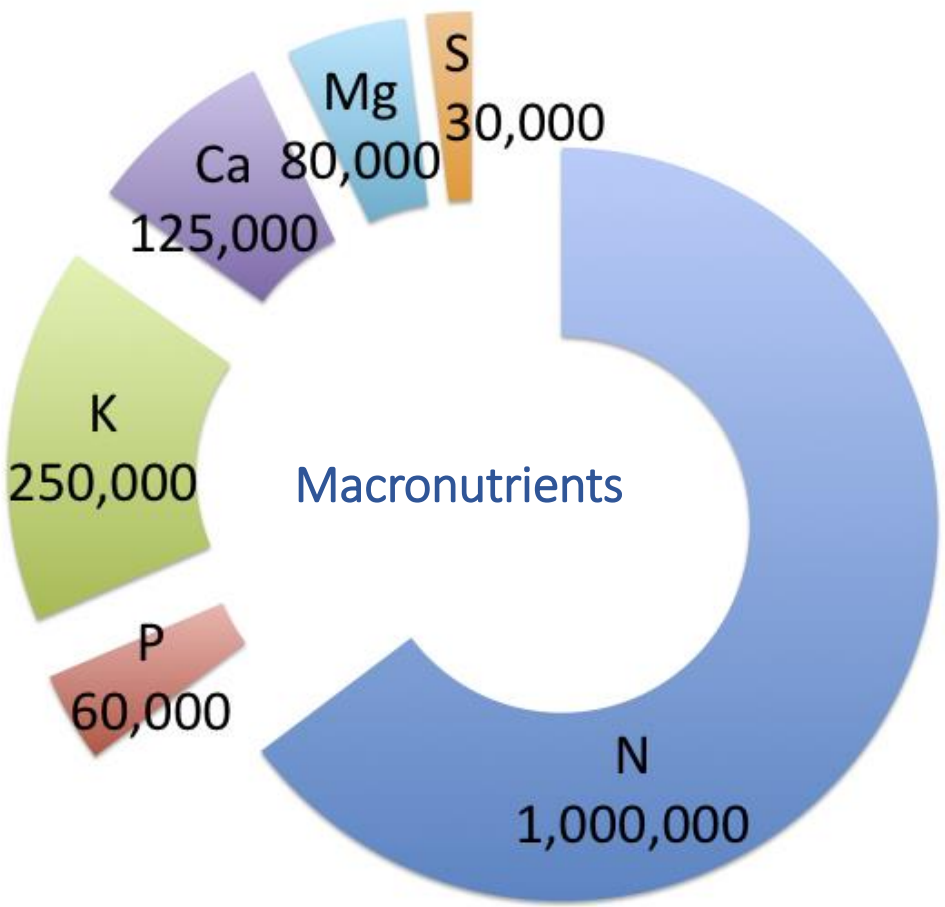
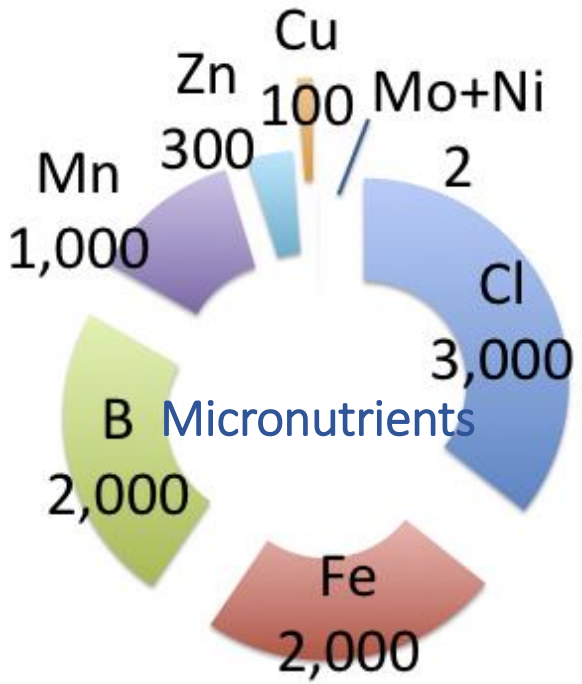
Relative content of macro- and micronutrients in plants



14 of 17 nutrients for mineral nutrition of plants come from the soil.

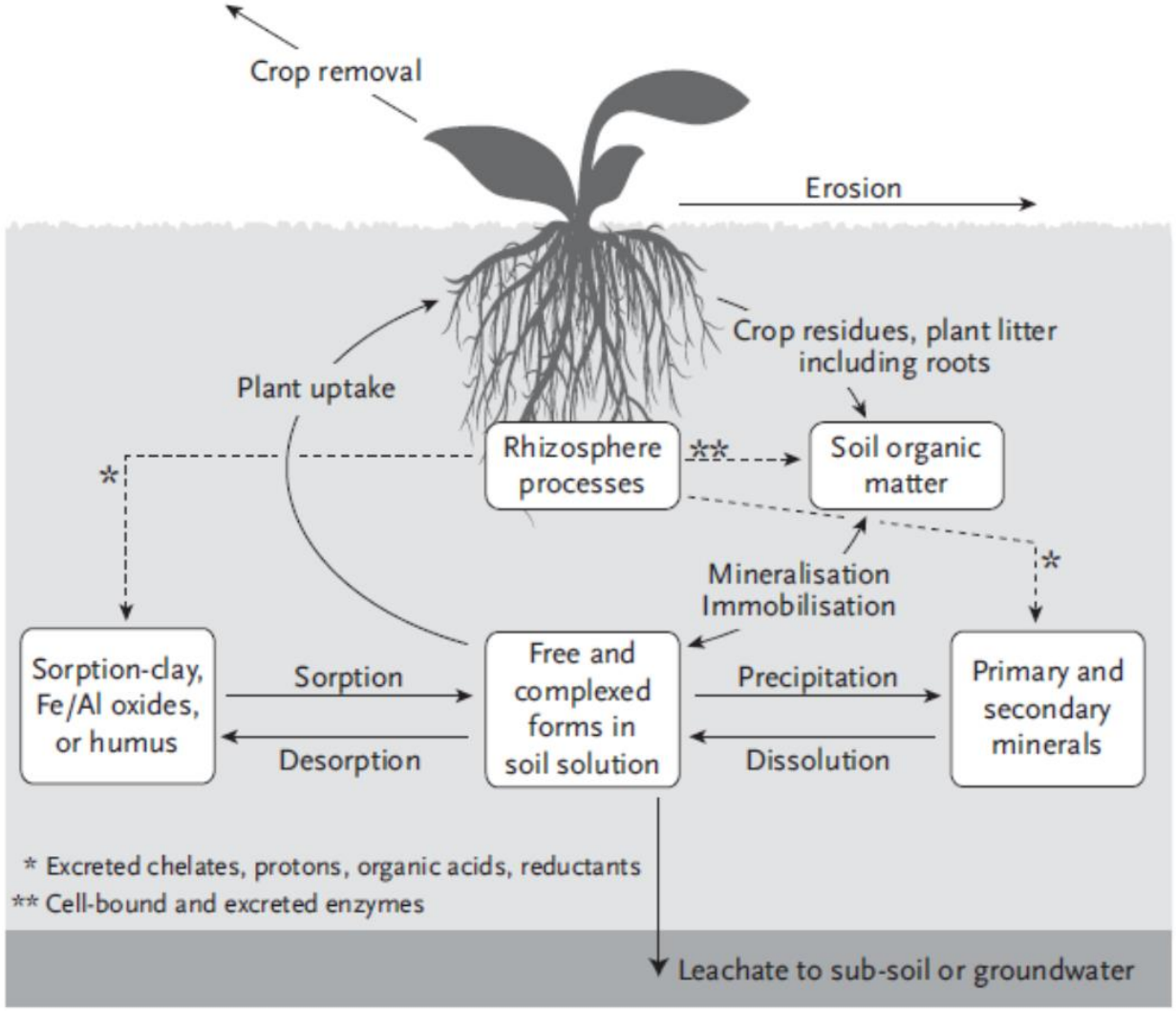
Micronutrients are as important as macronutrients and mesoelements, but plants need them in much smaller amounts.



IPNI, 2018.

Biogeochemical cycling of micronutrients

Aerobic soils



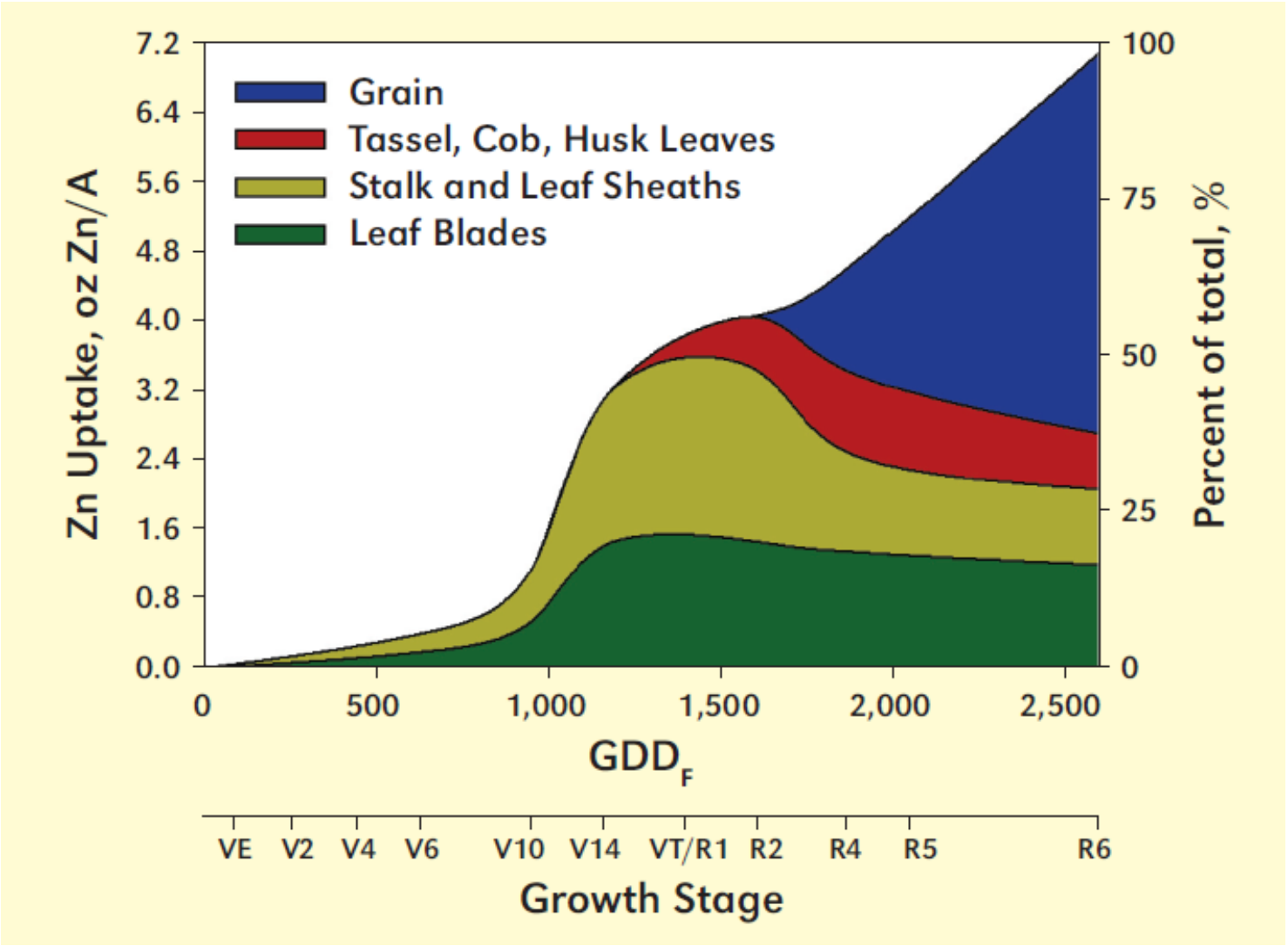
R.W. Bell and B. Dell, 2008

Micronutrient removal from soils by cereal crops

Crop		Yield, t/ha	B	Cu	Fe	Mn	Zn
			kg/ha				
Wheat	Grain	**4.0**	0.06	<0.10	0.50	0.20	0.20
	Straw	–	0.02	<0.10	0.20	0.30	0.10
Barley	Grain	**4.0**	0.10	<0.10	0.30	0.10	0.10
	Straw	–	0.02	<0.10	0.01	0.70	0.10
Maize	Grain	**9.5**	0.70	<0.10	0.20	0.10	0.20
	Straw	–	0.06	<0.10	1.00	1.70	0.30

McKenzie, 1992

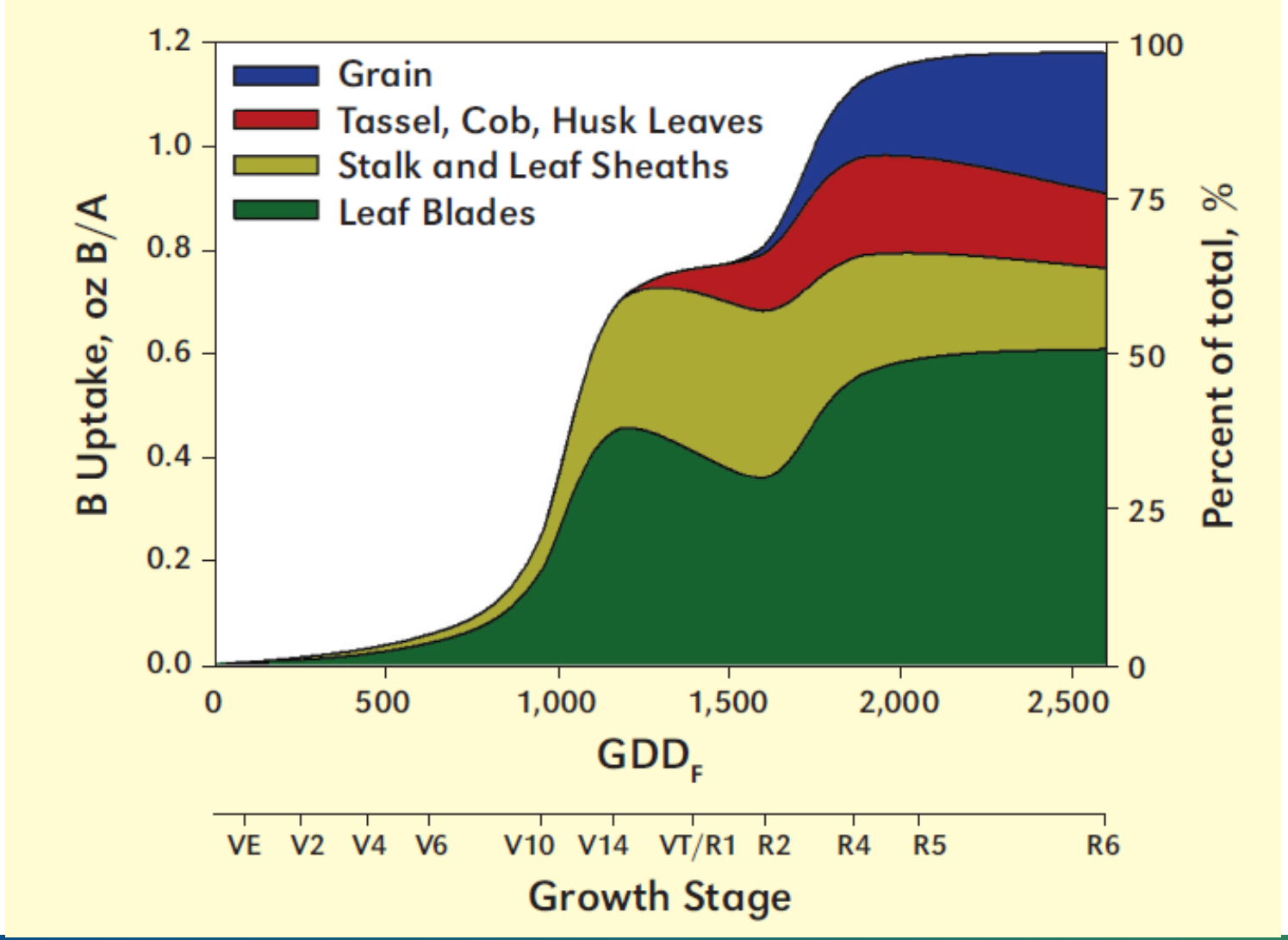
Changes in zinc uptake by maize



Values are averaged across six hybrids and two locations (Illinois, USA).

R.R. Bender et al, 2013

Changes in boron uptake by maize



Values are averaged across six hybrids and two locations (Illinois, USA).

R.R. Bender et al, 2013

PhosAgro's complex fertilizers with micronutrients

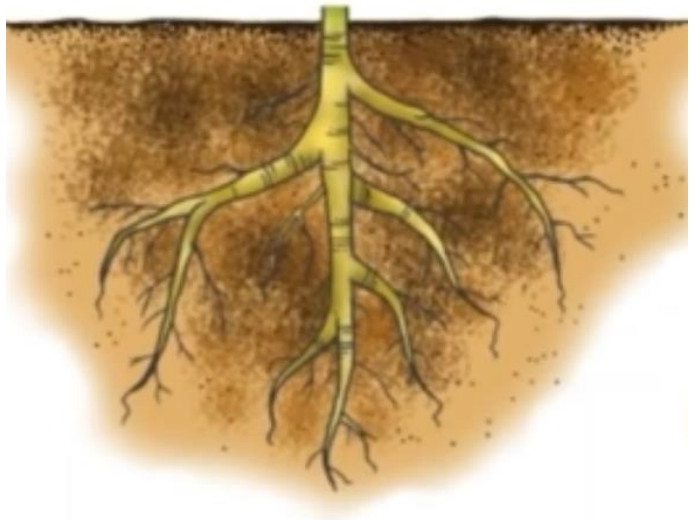
Liquid complex fertilizer: micronutrients can be added

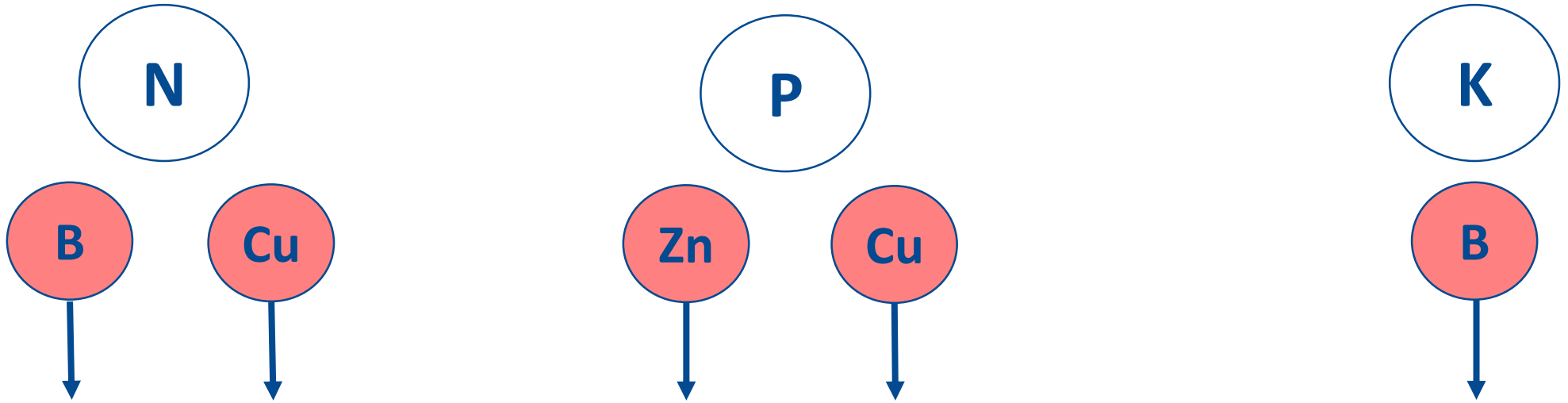
Zn	Zinc oxide, zinc sulphate, zinc citrate, zinc chelate*
B	Boric acid
Mn	Manganese oxide (IV), manganese sulphate, manganese chelate
Cu	Copper sulphate, copper citrate, copper chelate
Fe	Ferrous sulphate (II), ferrous chelate (III)

M. Opr, 2012

* Chelates – EDTA

Micronutrient availability factors: excess of macronutrients





V. Casarin, 2016

High doses of phosphorus may result in zinc deficiency

High content of P in the soil just like high doses of P-based fertilizers may result in a Zn deficiency in soils that are low in Zn and not treated with Zn-containing fertilizers.

Adriano and Murphy, 1967

Zinc deficiency impairs phosphorus regulation in plants

P_2O_5	Zn	Maize yield, t/ha	Content in leaves	
kg/ha*			P, %	Zn, mg/kg
0	0	6.33	0.14	12
0	11	6.40	0.16	24
90	0	4.58	0.73	10
90	11	10.16	0.41	17

Havlin et al, 1999

Cases of no exacerbation of zinc deficiency when high doses of phosphorus are applied

1) Vegetation experiment

Labile P content in the soil (Olsen test), mg/kg	P_2O_5 dosage, kg/ha	Zn content in maize seedlings, mg/kg
10		18
60		8
	129	21
	1,025	18

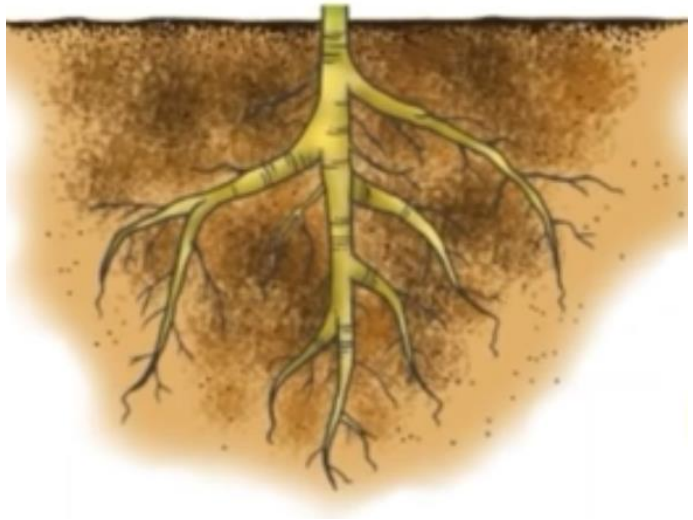
Shang and Bates, 1987

2) Prolonged field trial with very high phosphorus doses (**up to 202 kg of P_2O_5/ha**):

- ✓ zinc deficiency was not always severely exacerbated.

Mallarino, 1995

Micronutrient availability factors: weather conditions



Drought

B

Flood

Fe

Mn

Cold

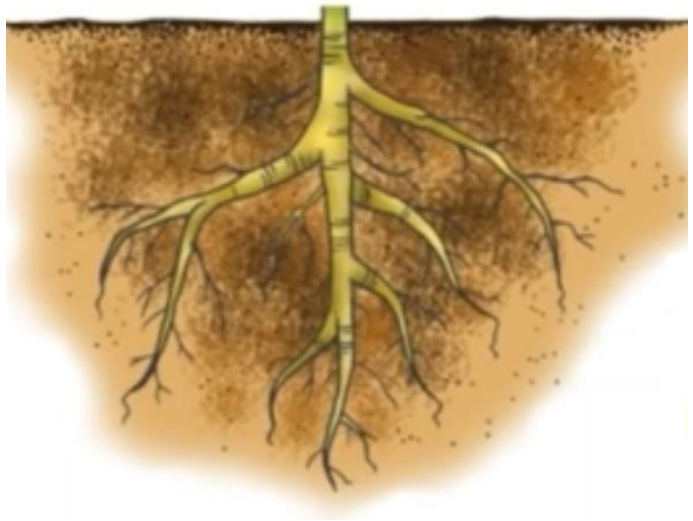
Cu

Mn

Zn

V. Casarin, 2016

Micronutrient availability factors: soil pH



Alkaline pH

Zn Cu Fe Mn

Acidic pH

Mo

The availability of boron (B) is reduced in both strongly alkaline and strongly acidic environments

V. Casarin, 2016

Other micronutrient availability factors

High doses of P:	**Stronger Mo absorption**
High doses of S–SO_4:	**Mo deficiency**
Excess of Zn and Ca:	**Cu deficiency**
Excess of Fe:	**Mn deficiency**
Excess of Mn:	**Fe deficiency**
Mo:	**Stronger N absorption (NO_3^- > NH_4^+)**

V. Casarin, 2016

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Thank you!