3rd European Conference on Copper in Plant Protection

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Copper risk minimization – lessons from history and future prospects – results and consequences from field studies on viticulture, orchards and hops

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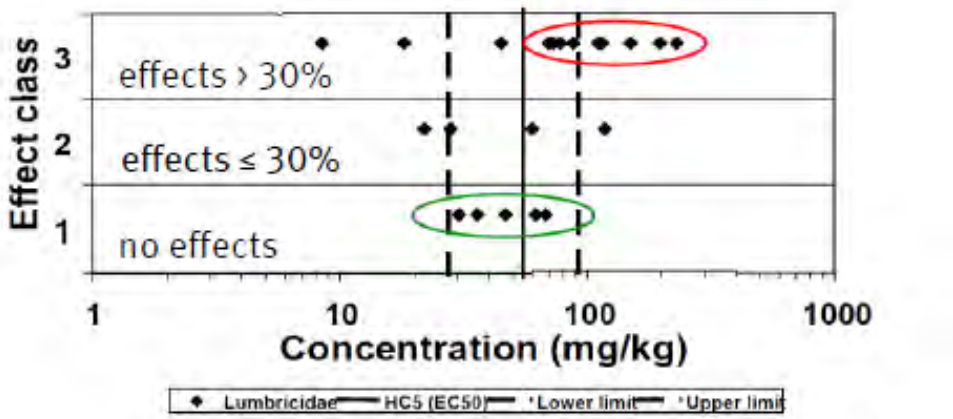
Effects of copper to earthworm community



from: Jänsch et al. (2009)

Largely pronounced effects of earthworms in the field

Cu > 100 mg/kg

What does it mean for perennial crops

- Estimation of the risk for soil organisms and their function in the field in viticulture.
- Presentation of the ecological situation at viticulture, orchards and hop, in consideration of the already existing high copper load.
- Assessment of the suitability of laboratory tests for the interpretation and specification of field surveys.

Copper study at JKI, 2009 - 2011

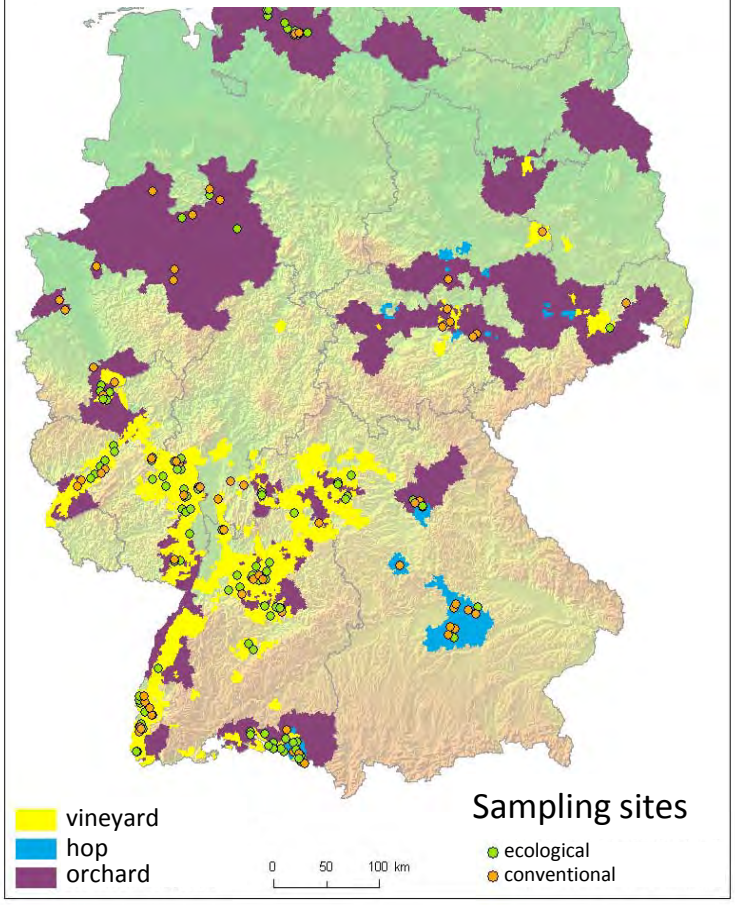
Chemical survey 1 - Pollution and exposition

Vineyards:
- ✓ 77 ecological
- ✓ 40 conventional
- ✓ 73 fallows
- ✓ 88 controls

Orchards:
- ✓ 57 ecological
- ✓ 30 conventional
- ✓ 39 fallows
- ✓ 50 controls

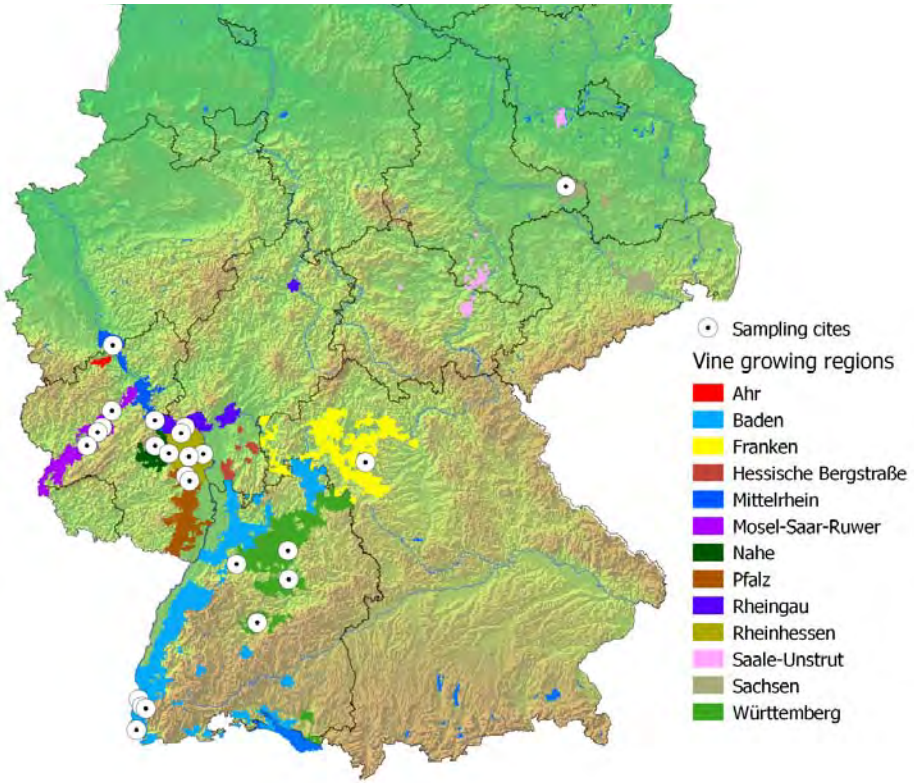
Hops:
- ✓ 6 ecological
- ✓ 16 conventional
- ✓ 12 fallows
- ✓ 16 controls

5 points per sampling site
0-5 cm and 5-20 cm depth,
with boring rod



Copper study at JKI, 2012 - 2014

Selected vineyards
✓25 ecological
✓5 conventional
✓24 fallows
✓24 controls



Chemical survey 2 → Total content and mobility of copper of soils

Biological survey → earthworms' distribution and microbial parameters

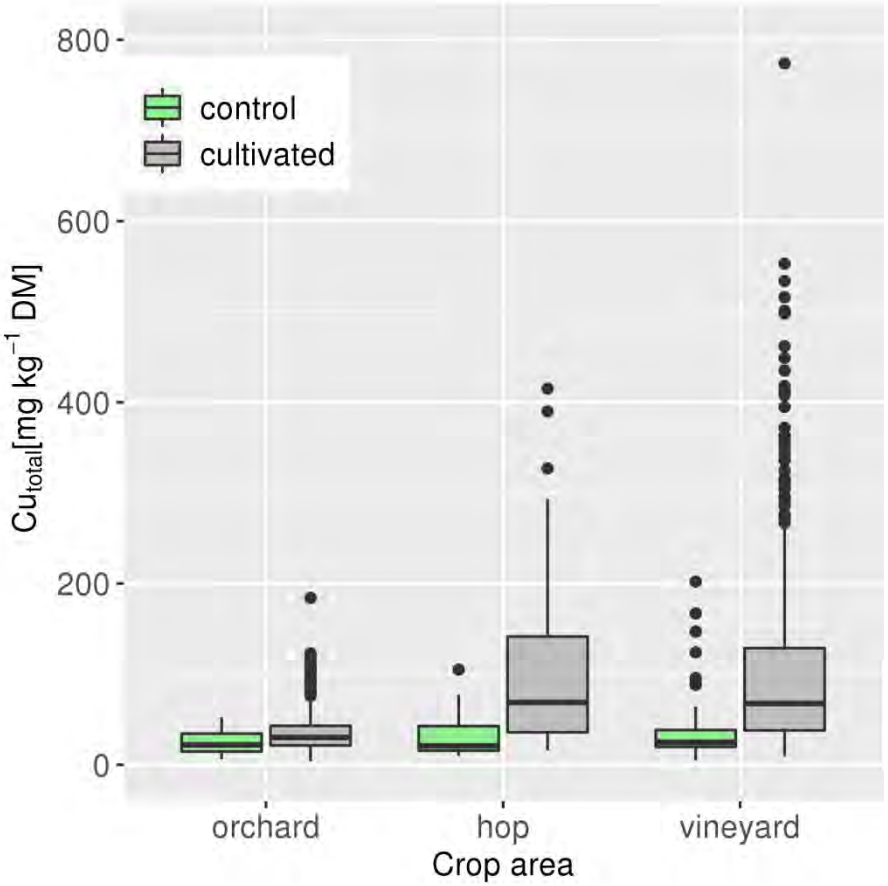
- ✓ 4 points per sampling site
- ✓ 4 x 0,25 m^2 excavated soil
- ✓ 20 cm depth



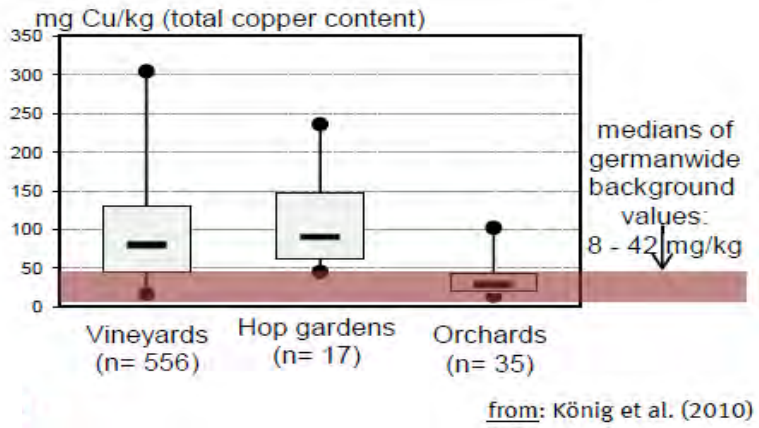
Laboratory tests → earthworms' behavior, growth and reproduction



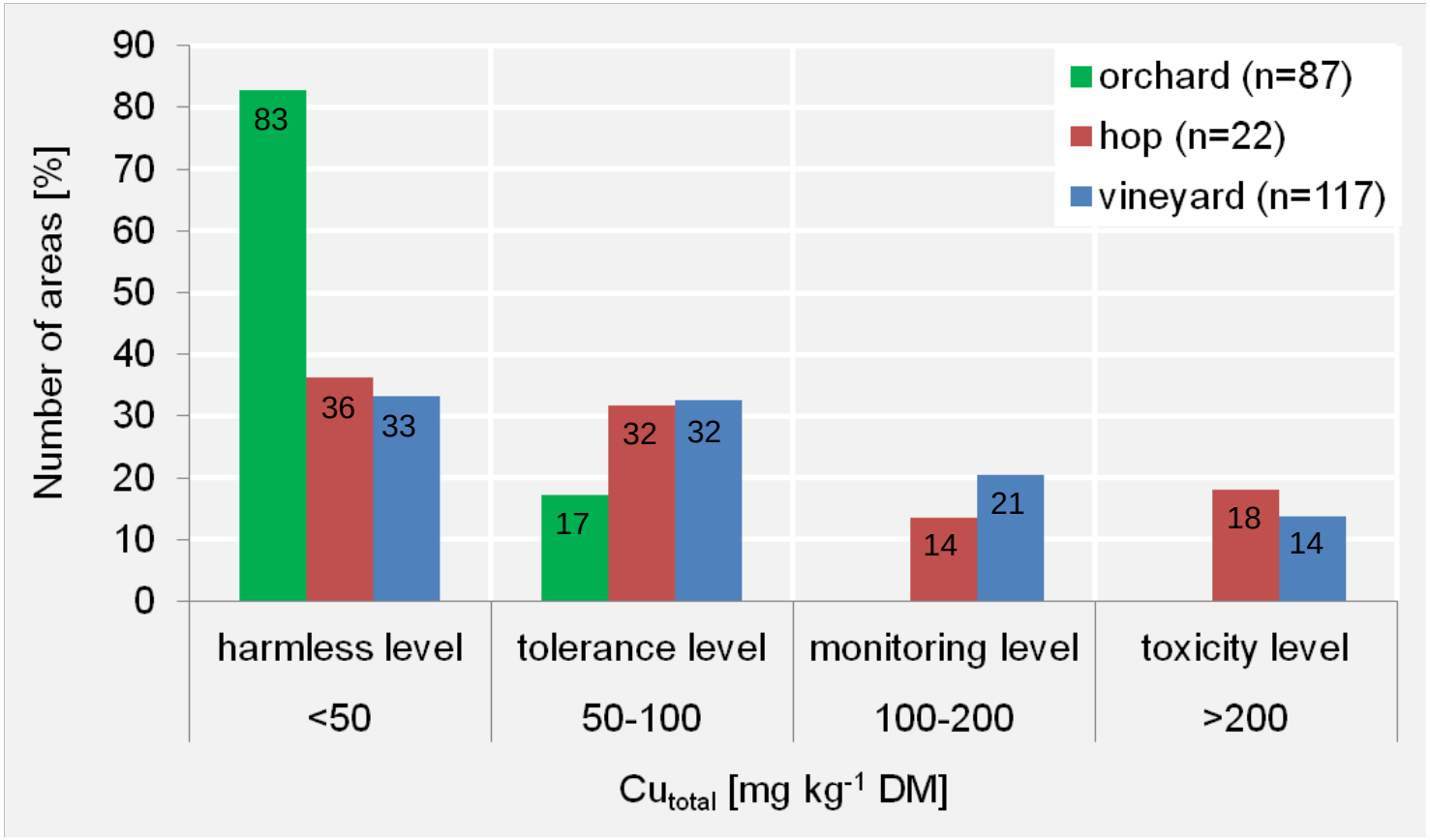
Chemical survey 1: Copper load



Crop area	Cu_{total} [mg kg^{-1} DM] Mean ± SD (n samples) , 20 cm depth	
	Background	**Cultivated sites**
Orchard	**25** ± 13 (50)	**35** ± 22 (423)
Hop	**32** ± 26 (16)	**99** ± 83 (110)
Vineyard	**36** ± 35 (88)	**102** ± 97 (578)

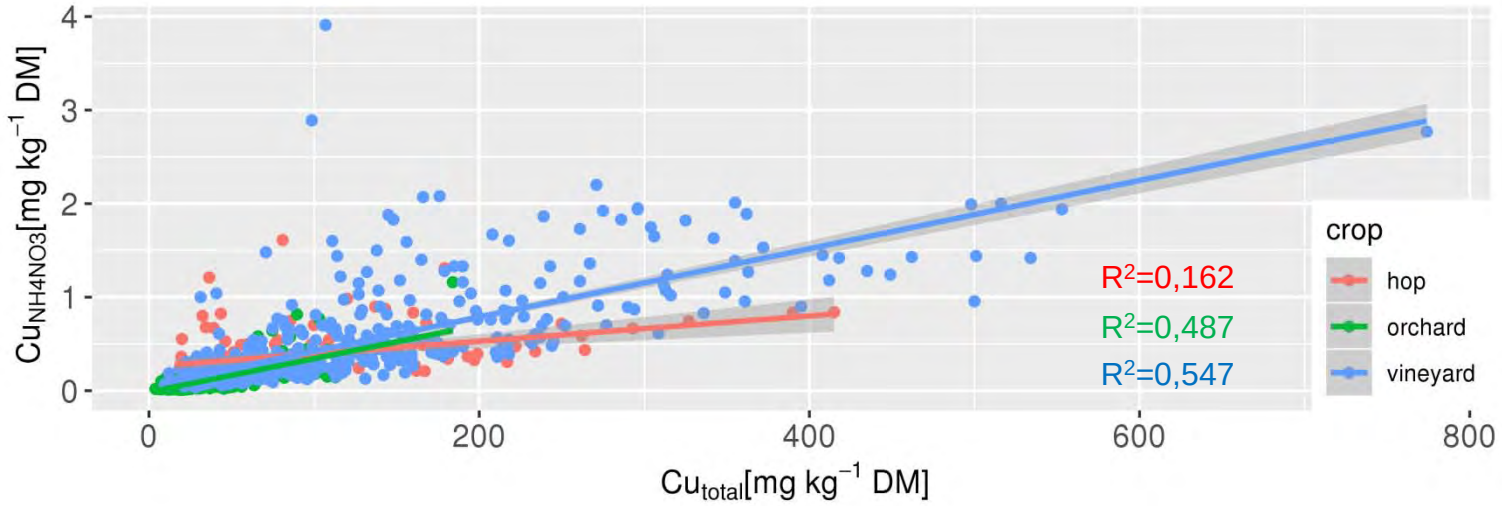


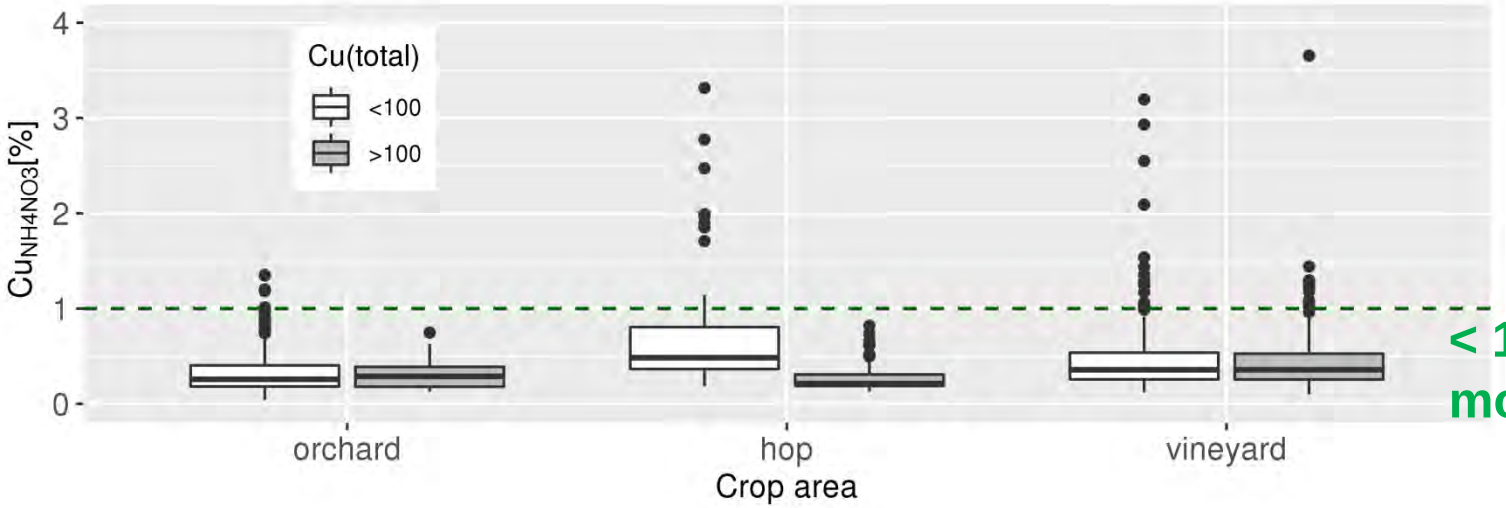
Chemical survey 1: Copper distribution



Classification according to guideline values of Eikmann and Kloke, 1993

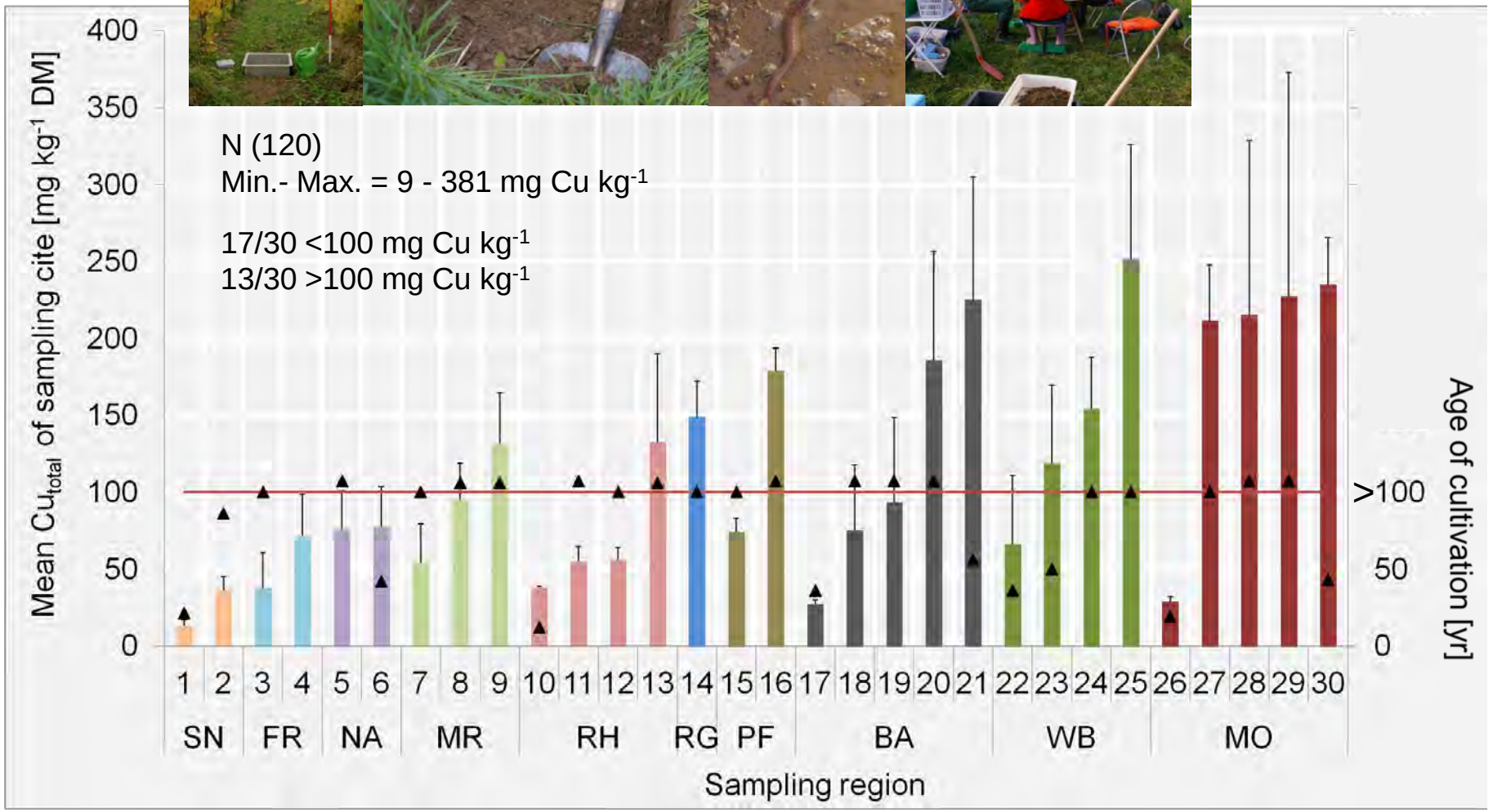
Chemical survey 1: Copper mobility ($Cu_{NH_4NO_3}$)





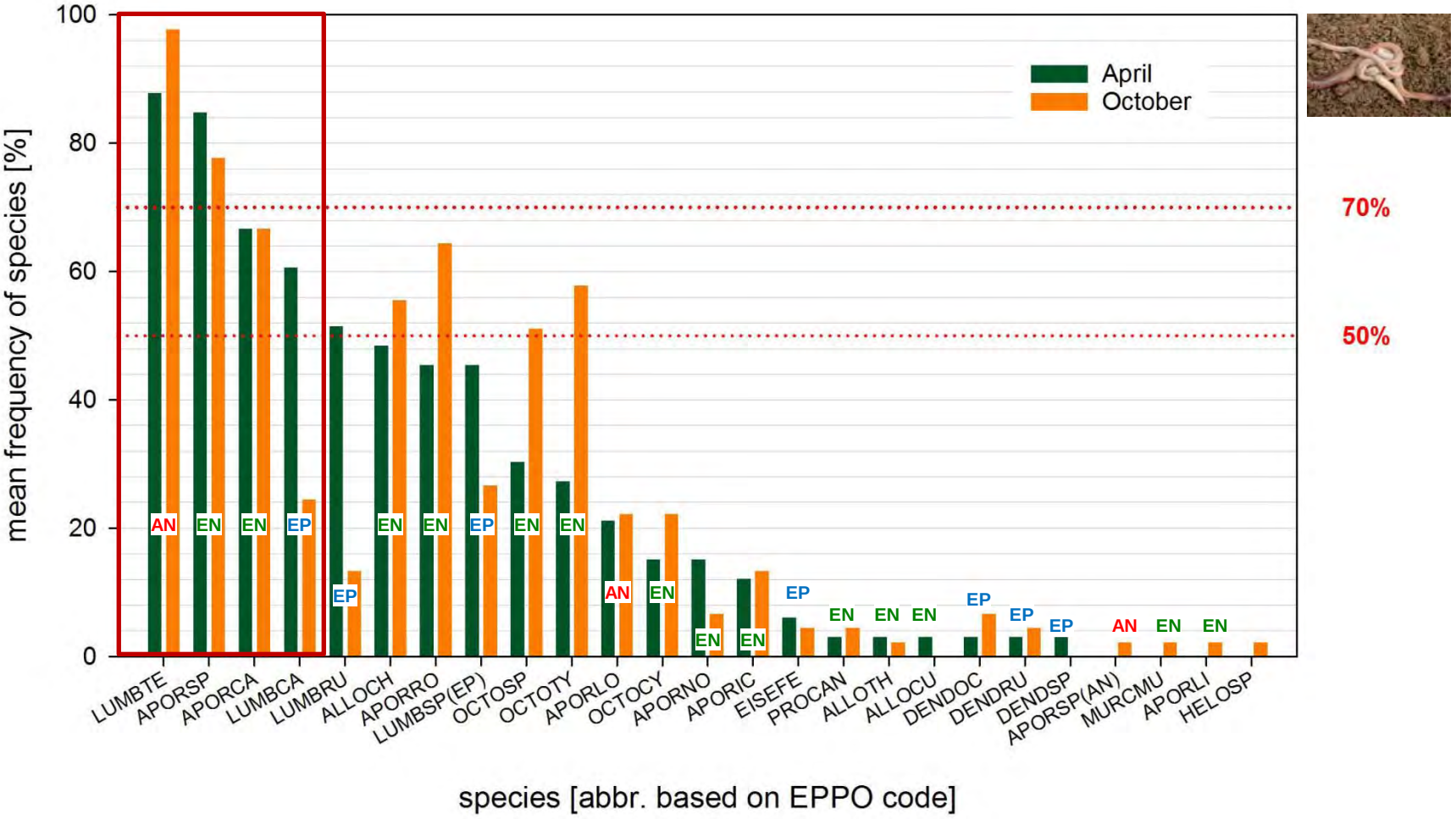
< 1 % mobile Cu

Chemical survey 2: Copper load

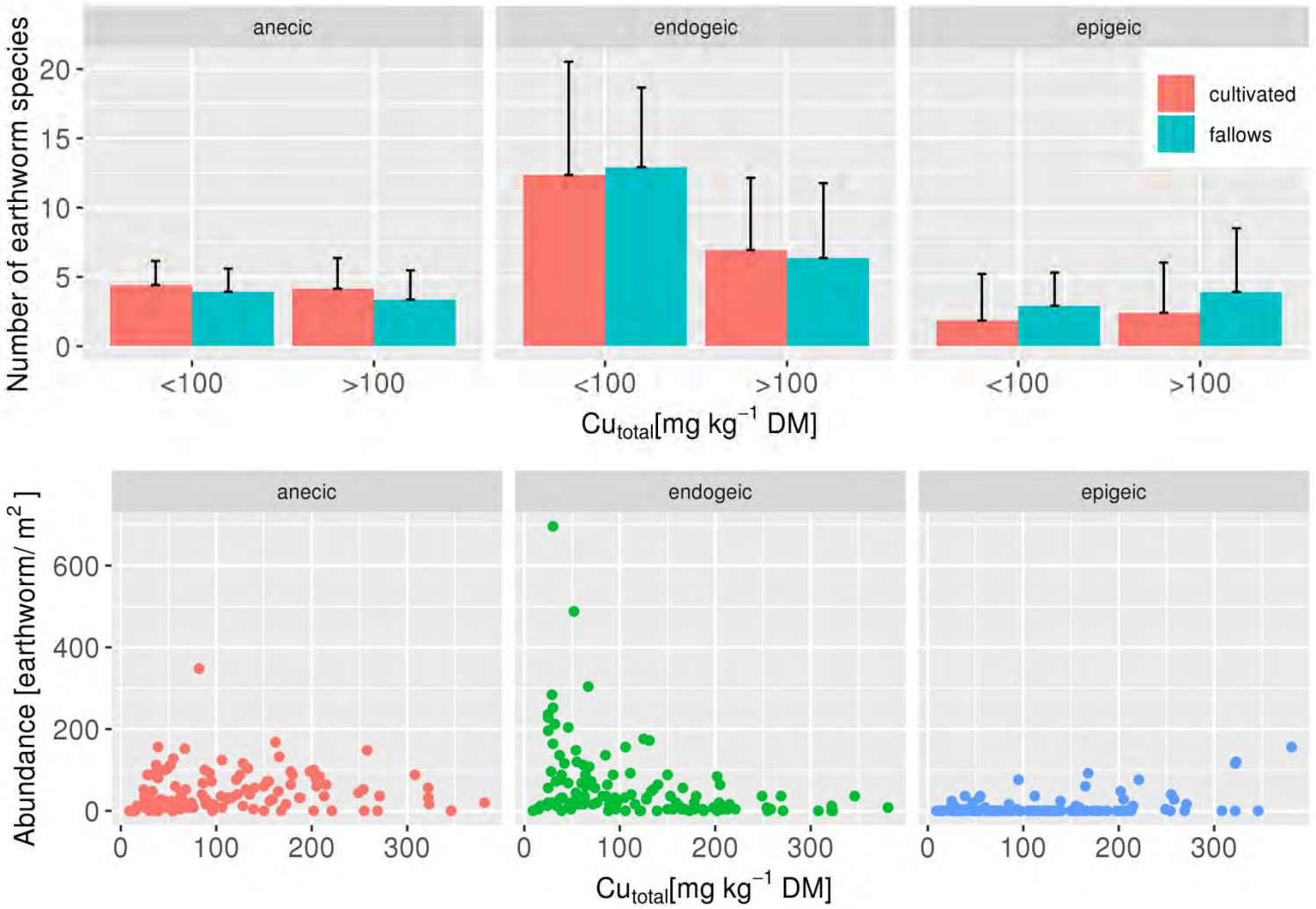


Biological survey: Main earthworm species in vineyards

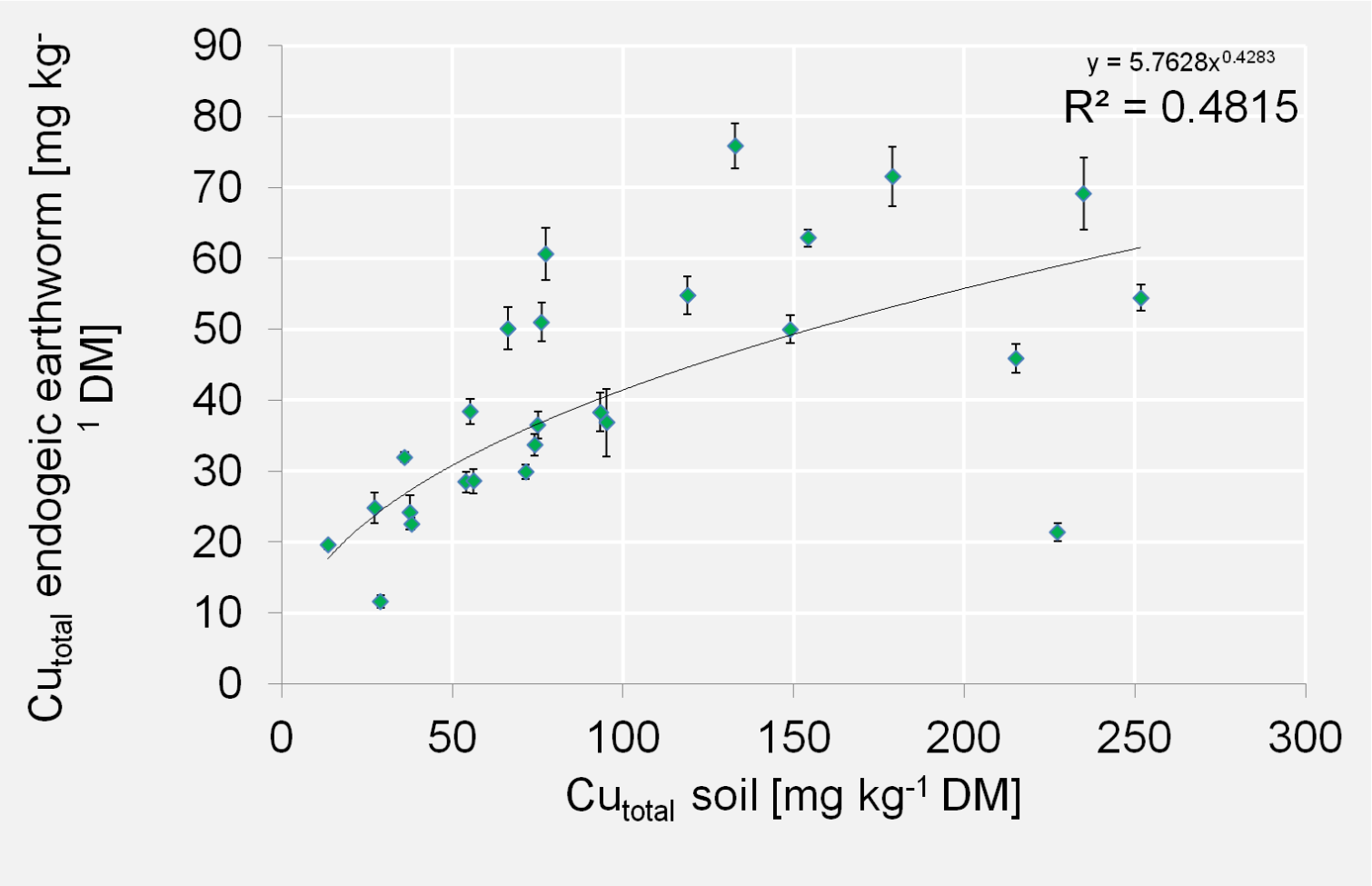
Frequency of single earthworm species in German vineyards
[> 70% = high, 50-70% = medium level of steadiness]



Earthworm species number and abundance per m^2 of vineyards (20 cm depth)

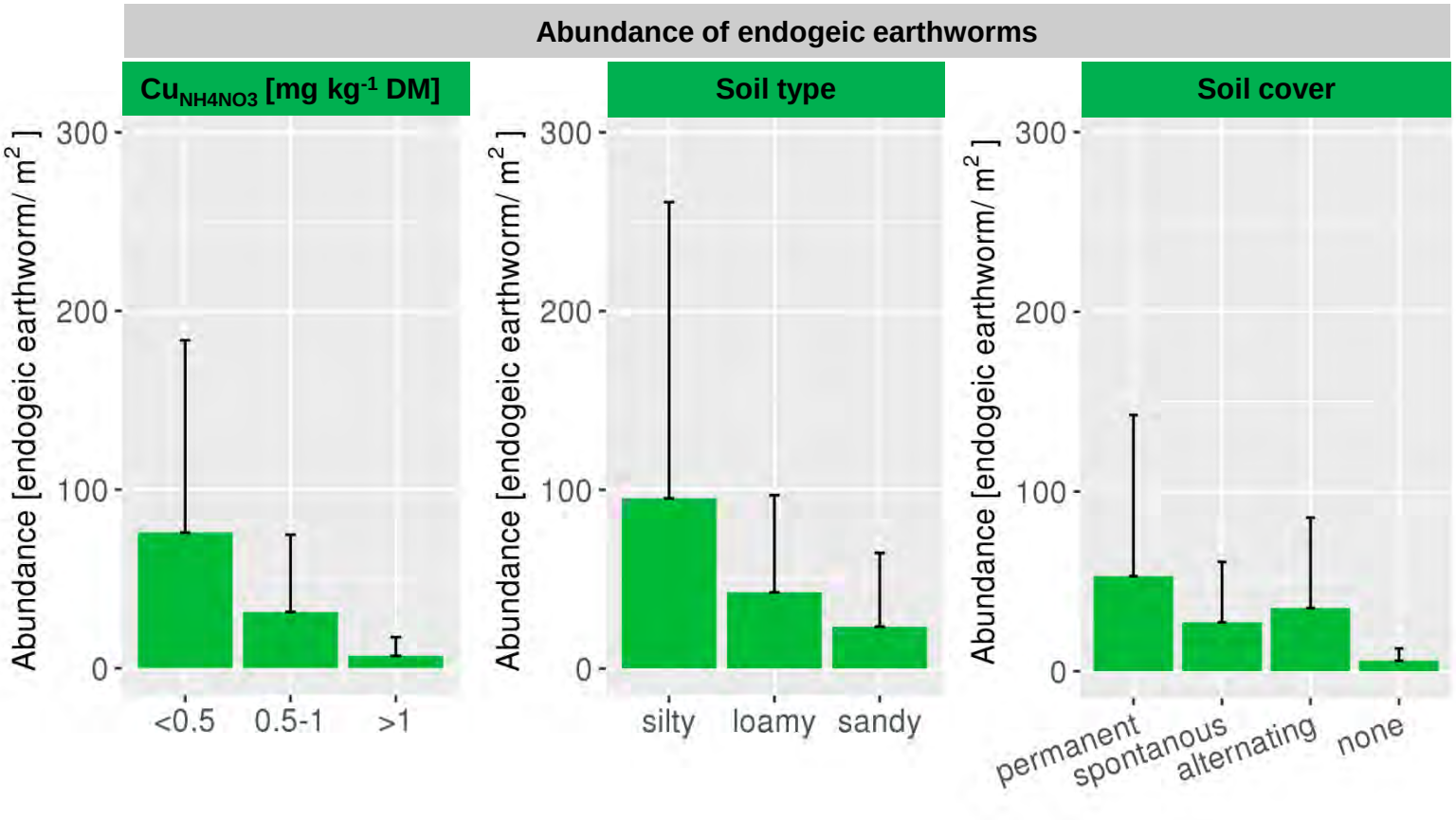


Biological survey: Copper accumulation in endogeic earthworm tissue



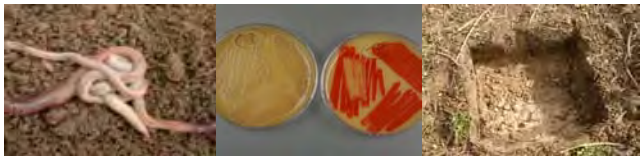
Copper accumulation is limited!

Biological survey: Earthworm abundance per m^2 of cultivated vineyards in relation to soil parameter



Complex relationships!

Biological survey: Total impacts on soil organisms



Spearman Correlation

high		significant		moderate		low		moderate		significant		high
-1		-0.8		-0.5		-0.2		0.2		0.5		0.8	1

			Pedological parameter										Element contents					
			pH	C	N	C/N	OM	H_2O	CEC	sand	clay	silt	Cu_{total}	Cu_{mobile}	Zn_{total}	Zn_{mobile}	Cd_{total}	Cd_{mobile}
Earthworms	epigeic	biomass																
		abundance																
		species number																
	anecic	biomass																
		abundance																
		species number																
	endogeic	biomass																
		abundance																
		species number																
Micro-organisms		qCO_2																
		C_{mic}																
		DHA																

Multifunctional impacts on soil organisms!

Laboratory tests: Avoidance – Growth - Reproduction

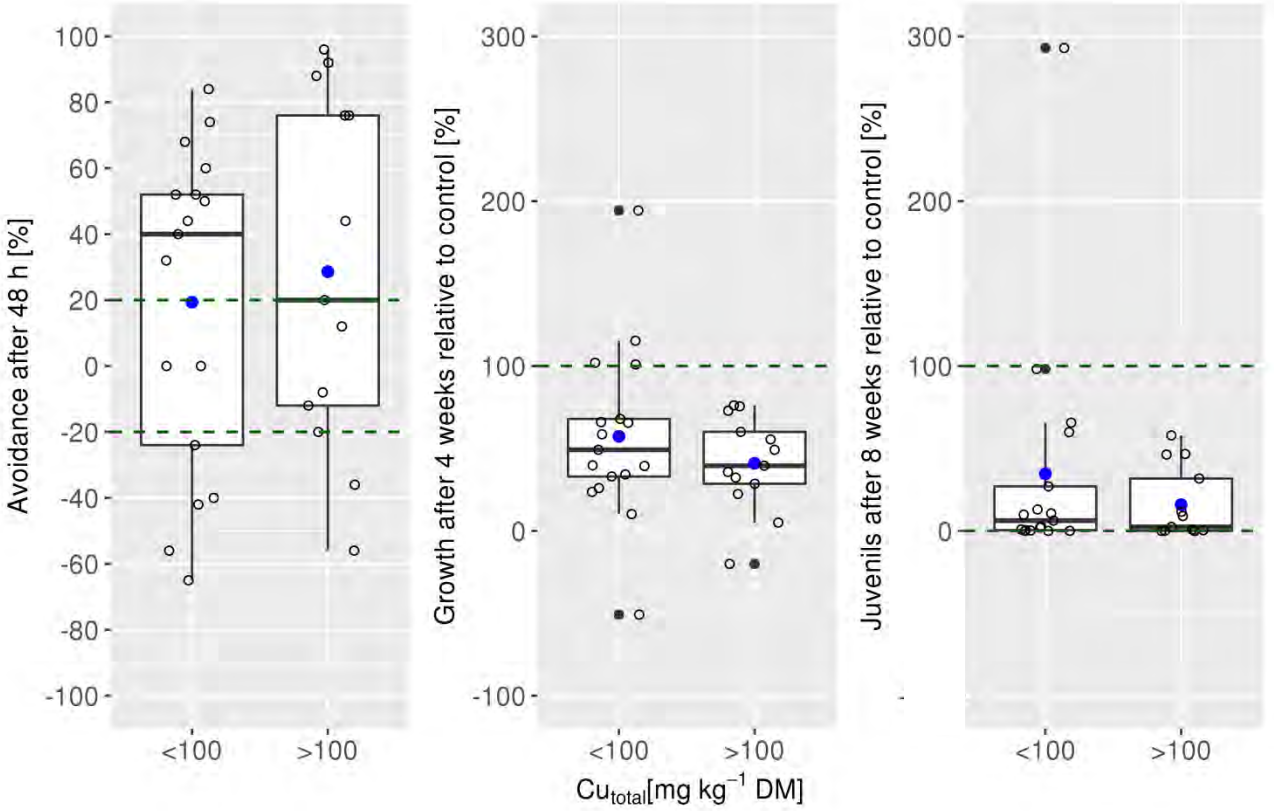
Eisenia andrei

non-adapted species

Control soil

- ✓ OM 3 %
- ✓ pH 5,8
- ✓ Cu 23 mg kg^{-1} soil
- ✓ silty sand (Su2)
- ✓ feed potato starch

Box whisker plots



Avoidance test (based on ISO 17512-1: 2008: -20 until 20 % equal distribution between control and vineyard soil
Reproduction test with *Eisenia andrei* (based on OECD 222: 2004): >100% = better than control and vice versa

FAZIT 1: Lessons from history

<u>In the perspective of chemistry</u>

Copper is quickly bound in soil, therefore very low mobility!

- ✓ Mobility in most cases <1%, depending on **site specific factors** (pH-value, organic matter, aging) and climatic conditions
- ✓ Heterogeneous distribution of copper is common
- ✓ Copper content: orchards < hop ≤ vineyard

<u>In the perspective of biology</u>

Earthworms still exist! → copper distribution, adaptation, compensation, behaviour

- ✓ Effect concentration <100 mg Cu kg^{-1}
  - → No effects
- ✓ Effect concentration >100 mg Cu kg^{-1} (maximum level of 381 mg Cu kg^{-1} soil)
  - → Halving of endogeic species numbers and low abundance
  - → Anecic and epigeic species numbers and abundances are unaffected
- ✓ **Earthworms and microorganisms are pretty influenced by multifunctional factors**
  - **→ Texture, soil cover, organic matter, moisture, other heavy metals**

FAZIT 2: Future prospects in case of **28 kg ha^{-1} until 2025**

<u>In the perspective of chemistry</u>

Historic copper load will influence significantly future observations!

- ✓ Precision spraying increases heterogeneity
  - → It promotes and secures “COMFORT ZONES”, mainly between rows
- ✓ Based on current knowledge about sampling sites
  - → Establishment of a chemical survey to monitor areas below or near 100 mg Cu kg^{-1} soil
  - → It doesn’t make sense to monitor sites with >150/200 mg Cu kg^{-1} soil, because of the very high historical copper load

<u>In the perspective of biology</u>

Effects on endogeic earthworms have to be monitored!

- ✓ Based on the chemical monitoring
  - → If the 100 mg Cu kg^{-1} - limit has been exceeded or is near by, biological monitoring should be implemented
- ✓ Soil cover enhances earthworm populations and should be mandatorily used generally
- ✓ The none-application of Cu-PPPs on contaminated areas would not lead to an ecological improvement → Nevertheless, we need alternative!

Thank you!
for your attention!

AND
a big thank to
ALL
diligent assistants

BÖLN
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ptble
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