Biochar and compost may both immobilize and mobilize copper in vineyard soils

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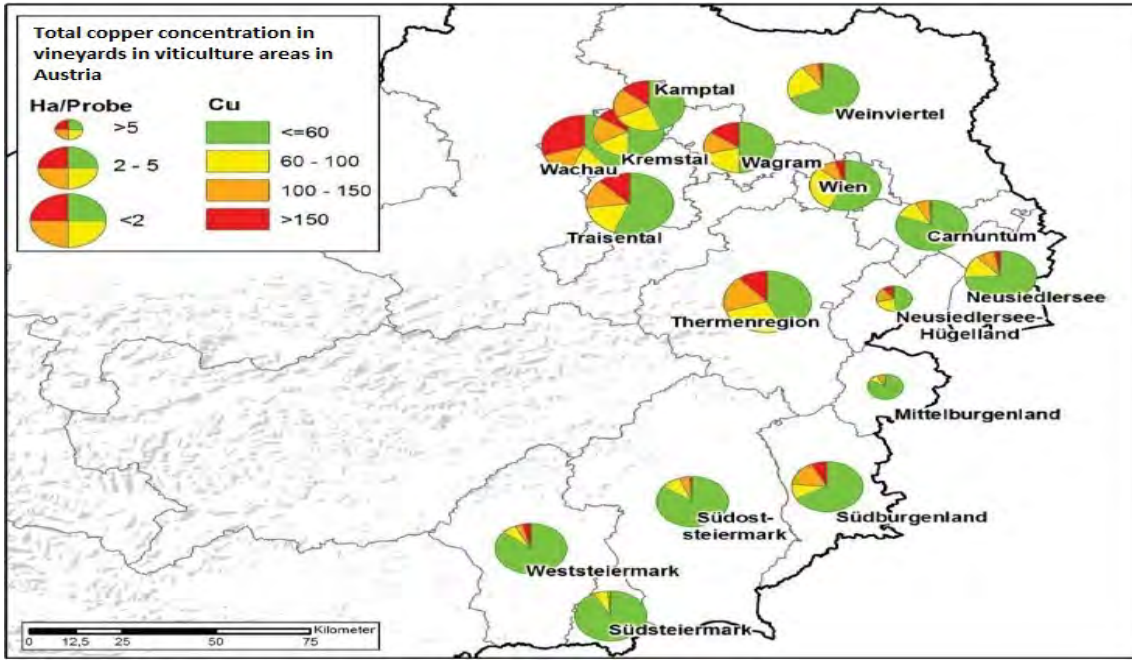
Cu-Concentrations in the soils of Austrian Wine-growing Regions

- **Analytical Basis**
  - comprehensive soil analysis survey about Cu-concentrations in agricultural regions
  - EDTA-extractable Cu (= exchangeable Cu)
  - **75 % percentile** for all analytical results: **61-75 EDTA-Cu (mg.kg^{-1})** in the most important wine growing regions



Source: Berger et al., 2012

THE WACHAU VALLEY OF THE RIVER DANUBE

- **26 % of Wachau vineyard soils show >150 mg Cu kg^{-1}** (= 390 ha; Berger et al., 2012)

Austrian standard for agricultural / horticultural soils: 100 mg Cu_{tot} kg^{-1}

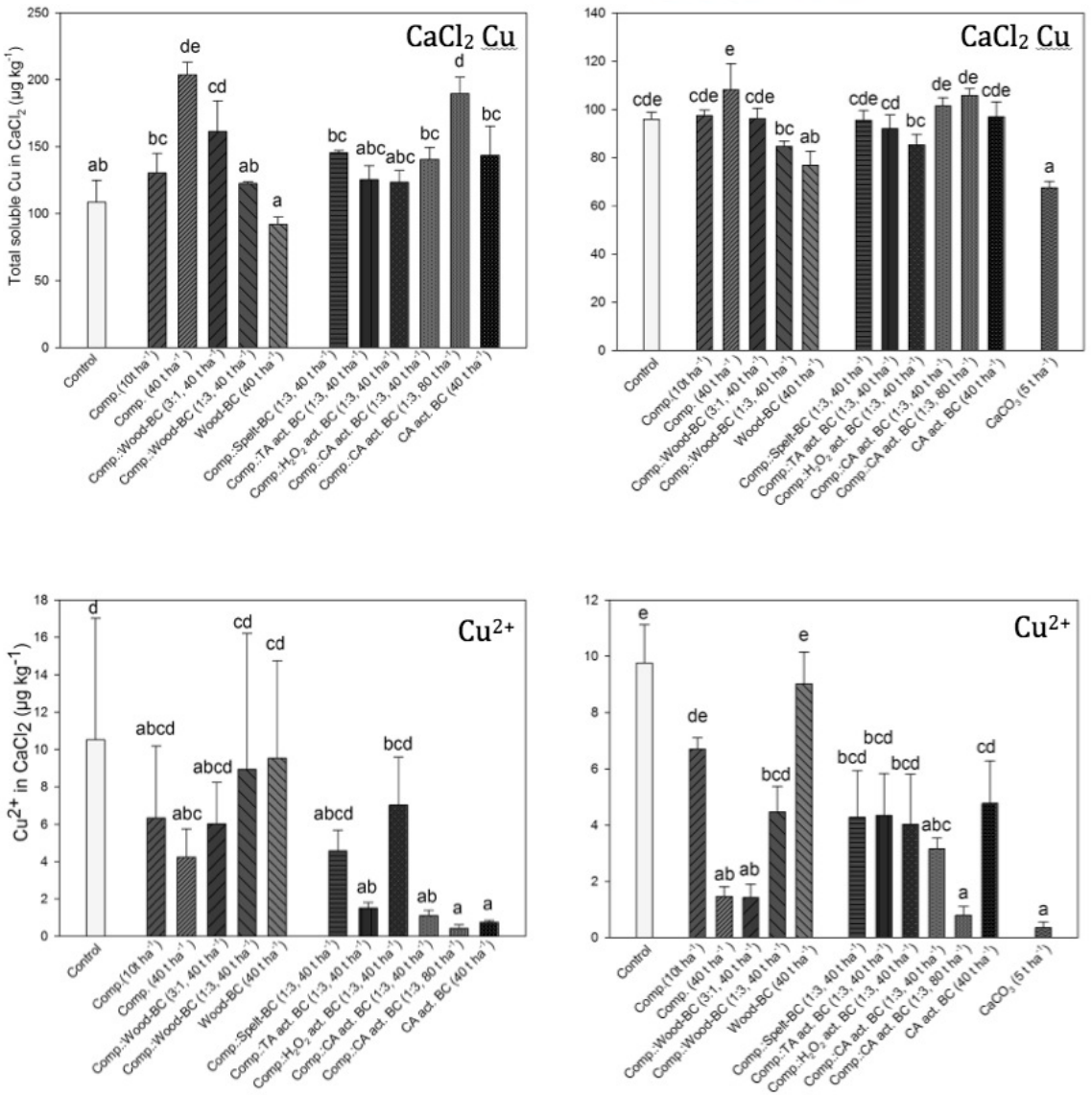
OBJECTIVES OF THIS STUDY

- **Decrease of Cu bioavailability** in vineyard soils by organic soil additives like biochar and compost
- **Study of soil additive effects** on
  - soil chemistry,
  - soil microbiology,
  - Cu leaching,
  - Cu uptake in plants

Results from Lab Experiments 2015-2017

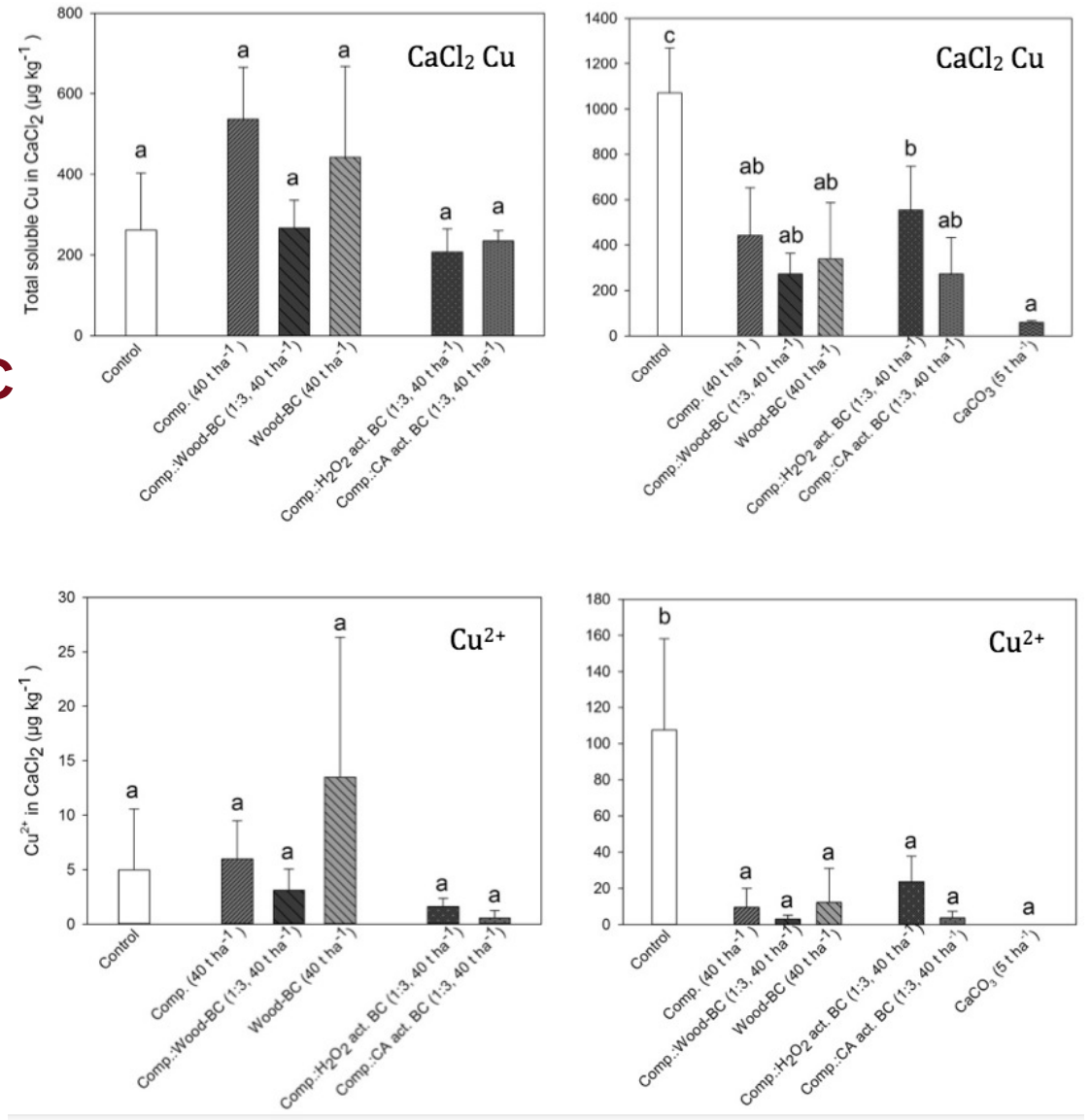
Biochar Decreases the Ecotoxicologically Relevant Cu-Fraction (Cu^{2+}) but not the Soluble Fraction

Rossatz (sandy soil, pH 7.3) **St. Stefan** (soil rich in C_{org}, pH 6.5

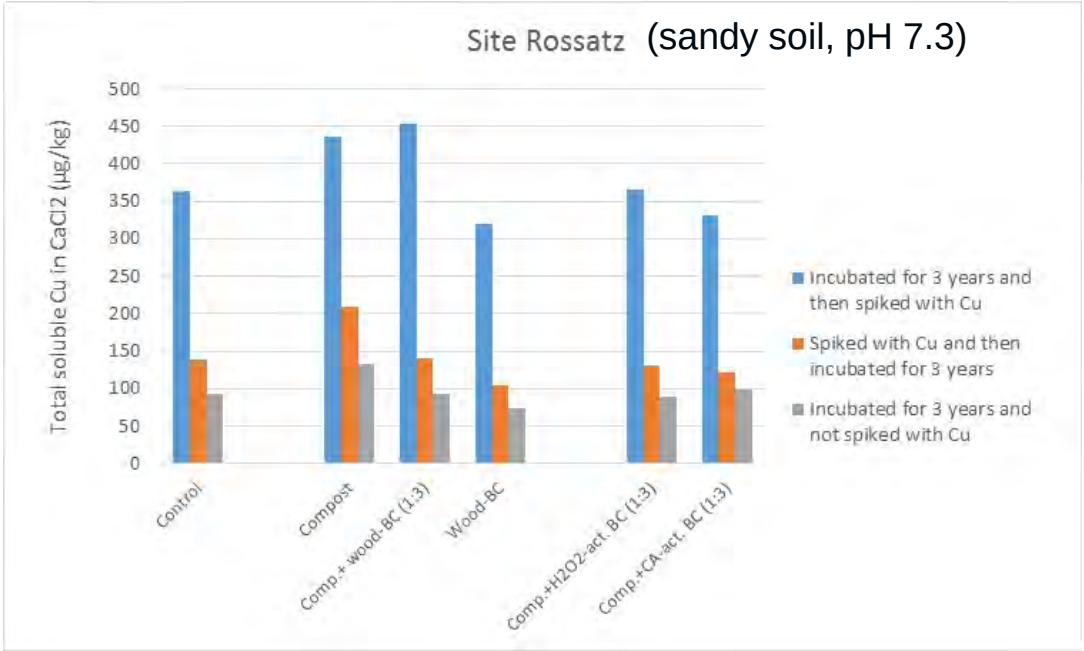


Freshly Added Cu (+250 mg/kg): Amendments Immobilise more Effectively in Acidic Soil

Rossatz (sandy soil, pH 7.3) St. Stefan (soil rich in C_{org}, pH 6.5)



3 Years after: how Effective Remain the Soil Additives?



Analyses of exchangeable Cu after 3 years

Grey: original soil

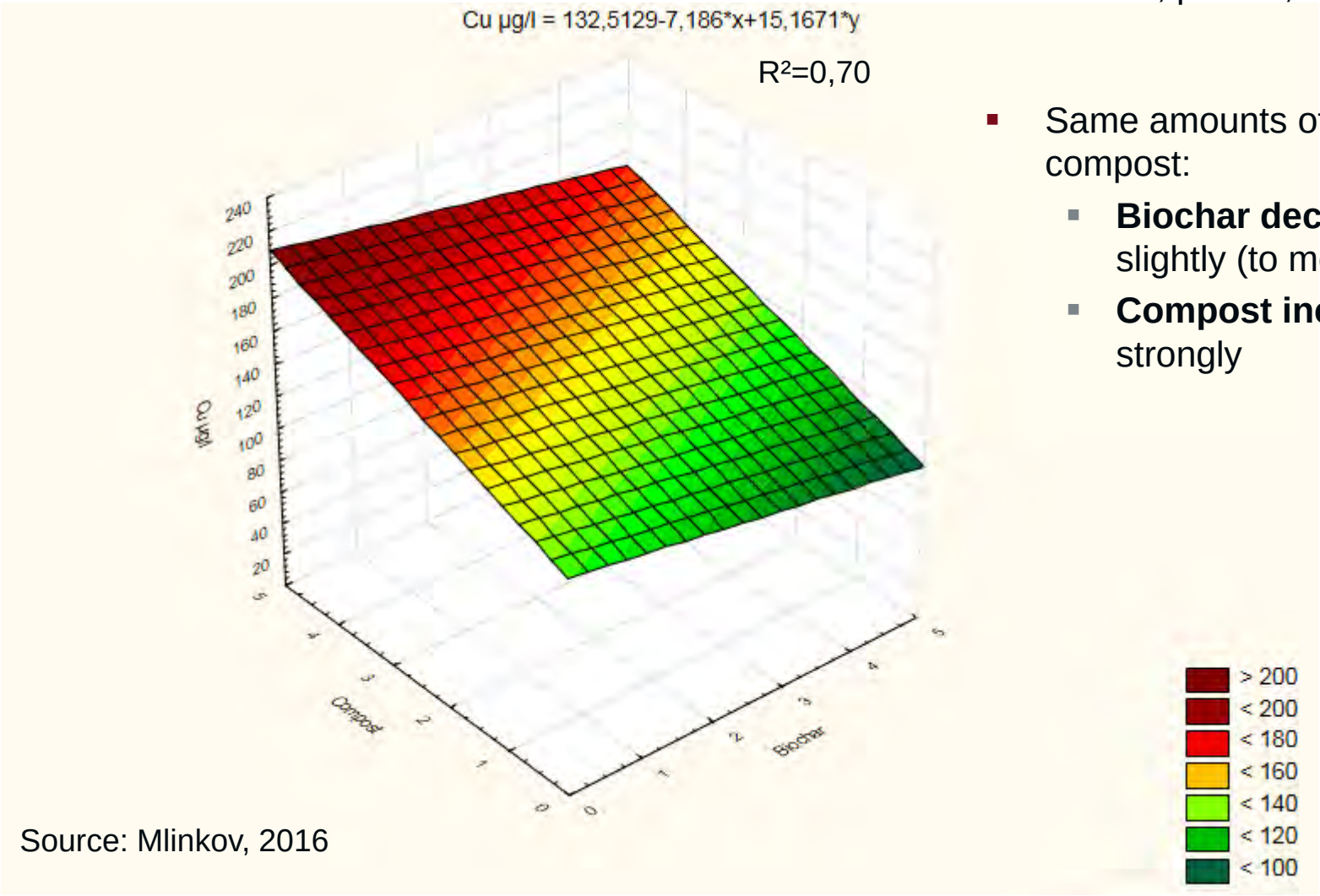
Orange: original soil + Cu addition at the start of the incubation

Blue: original soil + Cu addition 6 weeks before the end of the incubation

Results from a Pot Experiment 2015-2016

Dependence of Cu in Soil Pore Water (µg/L) on Amendment Concentrations (in % w/w)

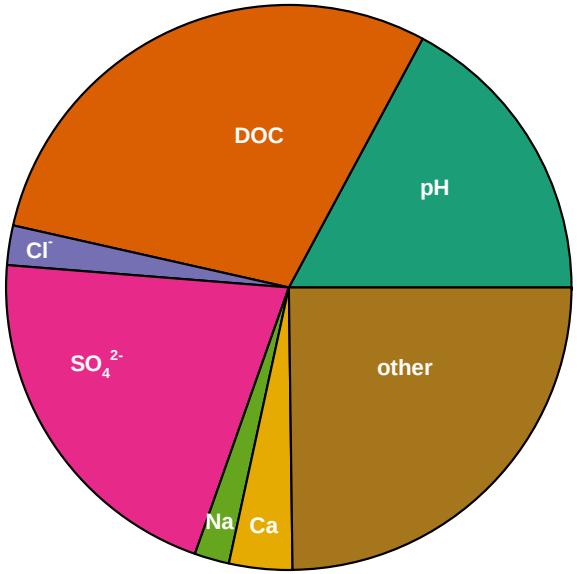
Rossatz soil, pH = 7,3



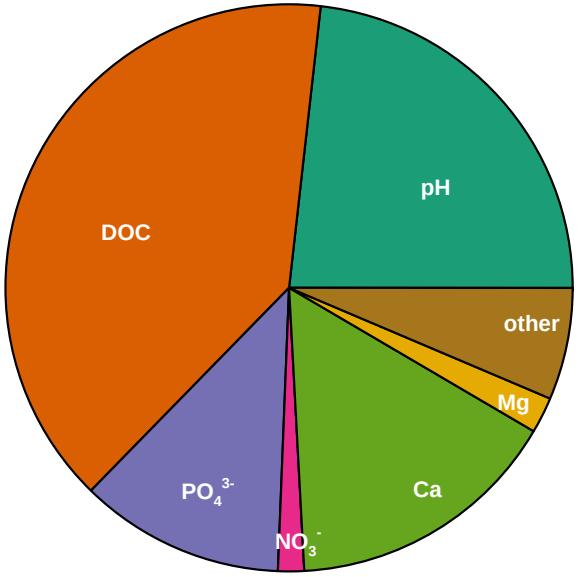
- Same amounts of biochar and compost:
  - **Biochar decreases** Cu slightly (to moderately)
  - **Compost increases** Cu strongly

Source: Mlinkov, 2016

Which Soil Parameters Affect soluble Cu in Soil Leachates?

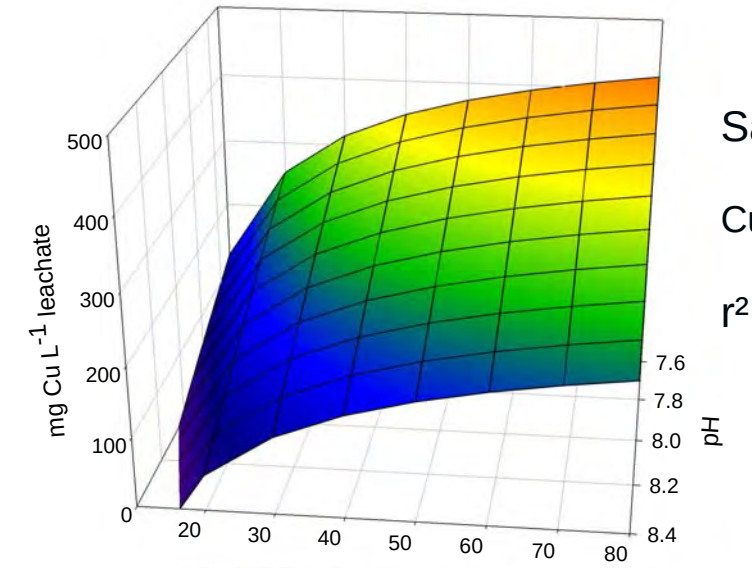


Sandy soil, pH 7.3:
pH and DOC dominate
Regression model: $r^2 = 0.75$



Soil rich in Corg, pH 6.5:
pH and DOC dominate, too
Regression model: $r^2 = 0.94$

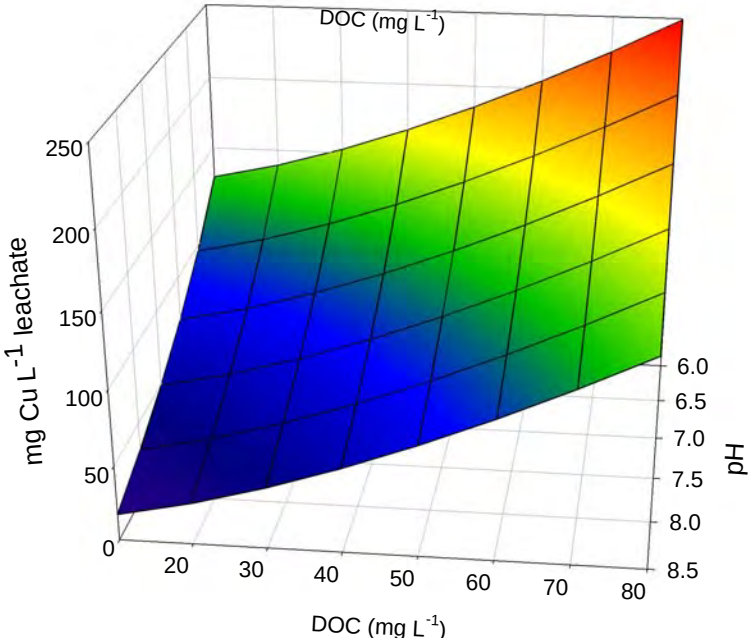
Dependence of Soluble Cu in Soil on pH and DOC



Sandy soil, pH 7.3:

Cu_{total} (mg L^{-1}) = 1083,5 - 1,1891 pH^3 - 1465,9 / DOC^0,5 (mg L^{-1})

r^2 = 0,66

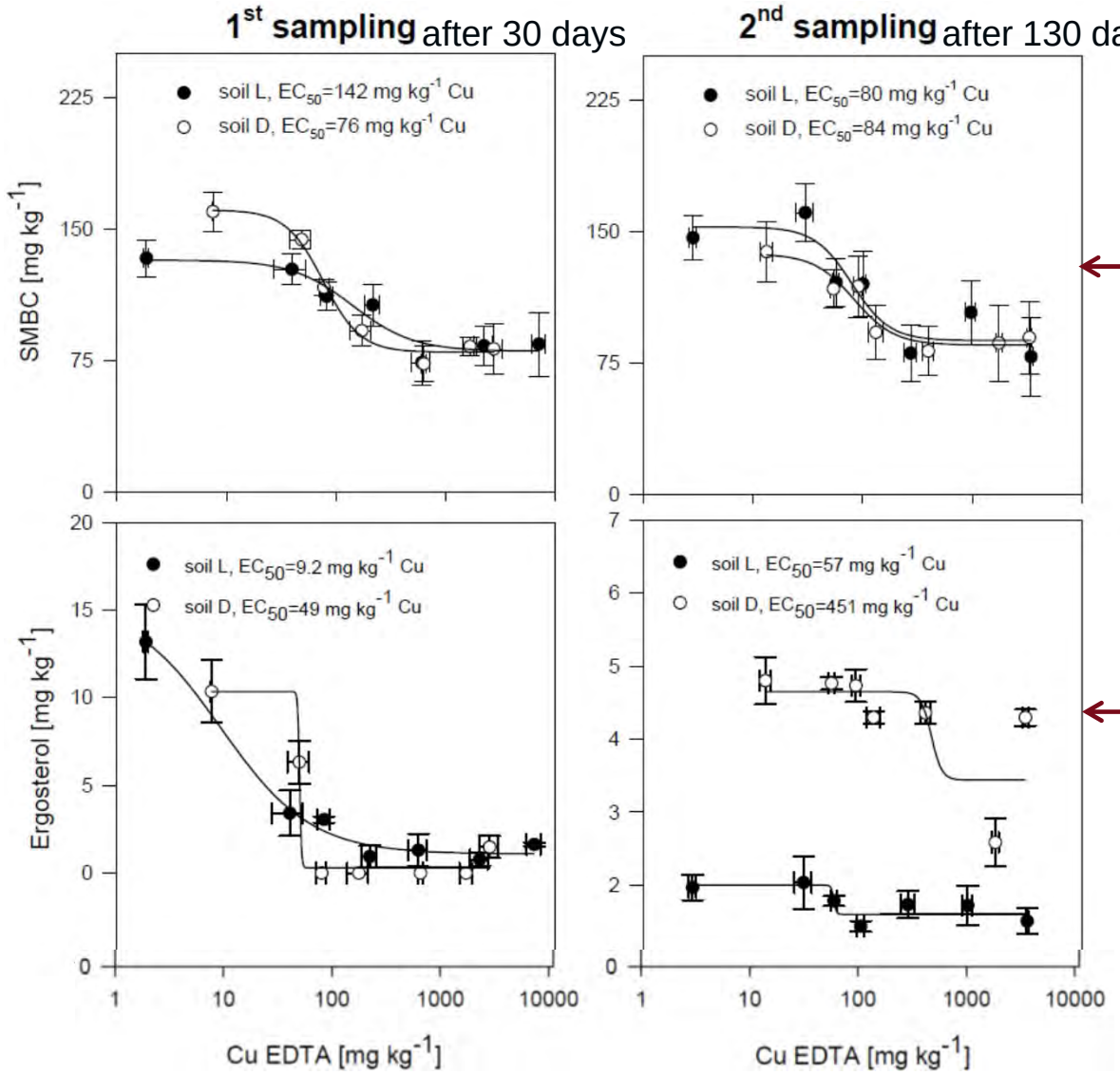


Soil rich in Corg, pH 6.5:

Cu_{total} (mg L^{-1}) = -98,79 + 8000 / pH^2 + 0,1757 DOC^1,5 (mg L^{-1})

r^2 = 0,89

Ecotoxicological Analysis of Cu in Soil: Fungal Sensitivity Decreases over Time

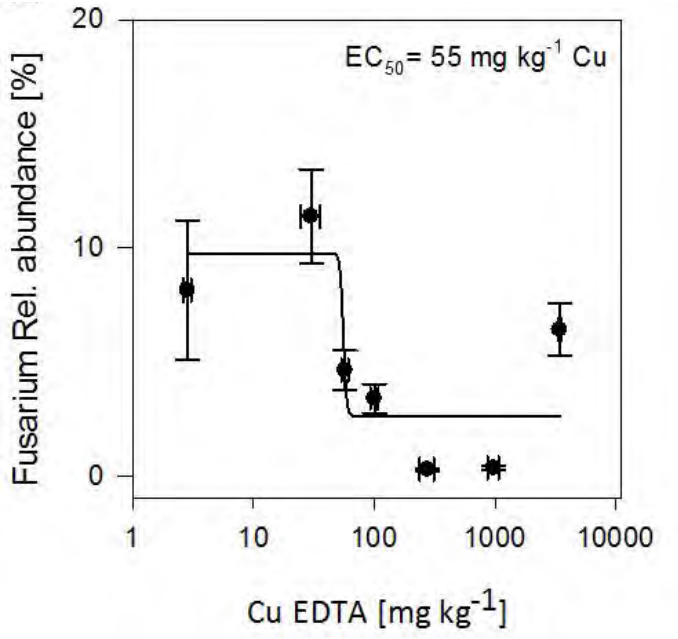


← Soil Microbial Biomass Carbon

EC_{50}: Concentration with 50 % of maximum effect
Cu as EDTA-Cu
Soil L: acid
Soil D: neutral

← Ergosterol as Fungal Biomarker

Positive Side-Effects: Also Fusarium is Sensitive against Cu



Soil L (acid)

OTU	genus	species
13	Fusarium	oxysporum
131	Fusarium	sp.
201	Fusarium	graminearum complex
23	Fusarium	sp.
28	Fusarium	sp.
42	Fusarium	sp.
68	Fusarium	venenatum
96	Fusarium	solani

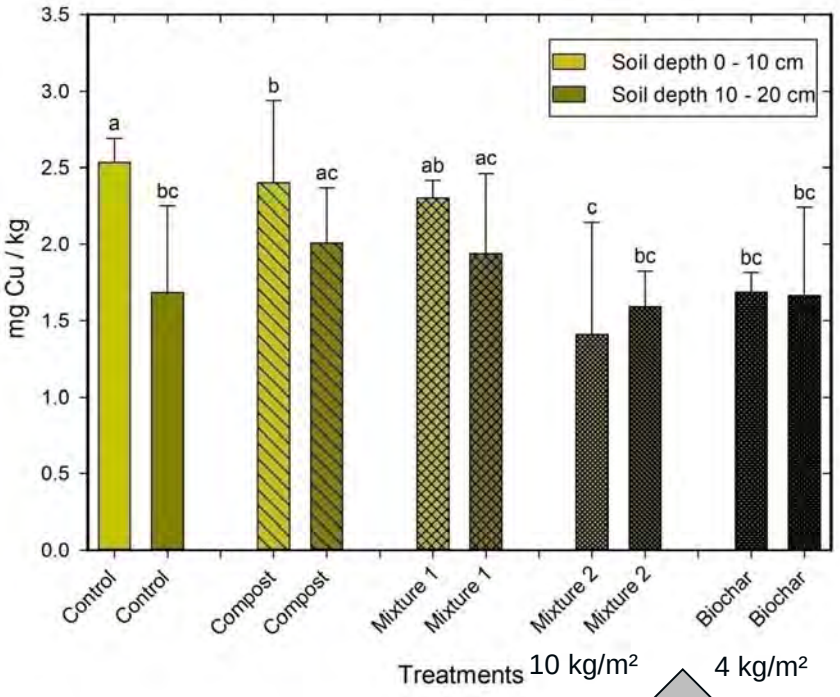
List of identified *Fusarium*-species that are summarized in the above figure

Results from a Field Experiment 2015-2017

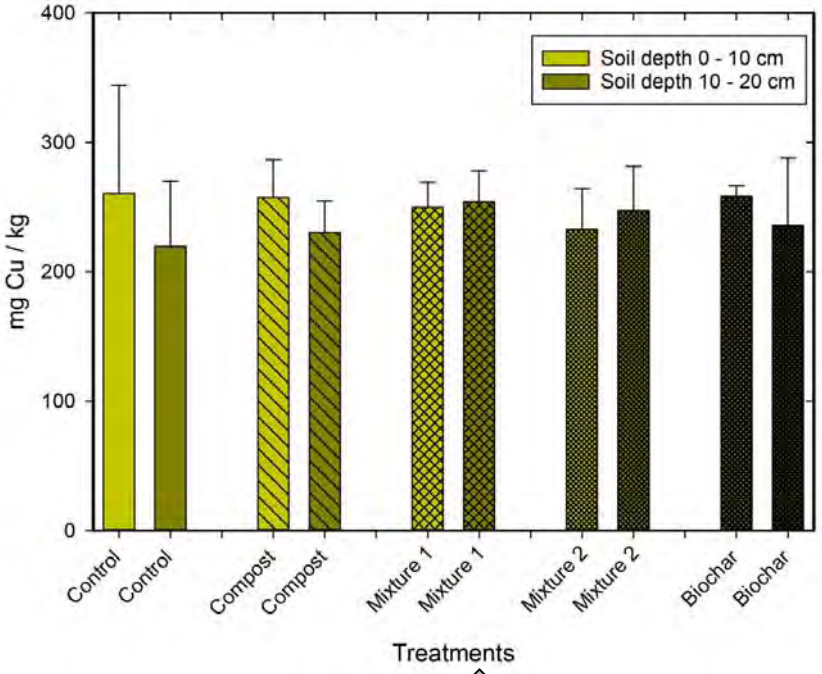
COPPER IN THIS VINEYARD SOIL

AUSTRIAN INSTITUTE OF TECHNOLOGY

Bioavailable Cu - amount



Cu_{tot}- concentration



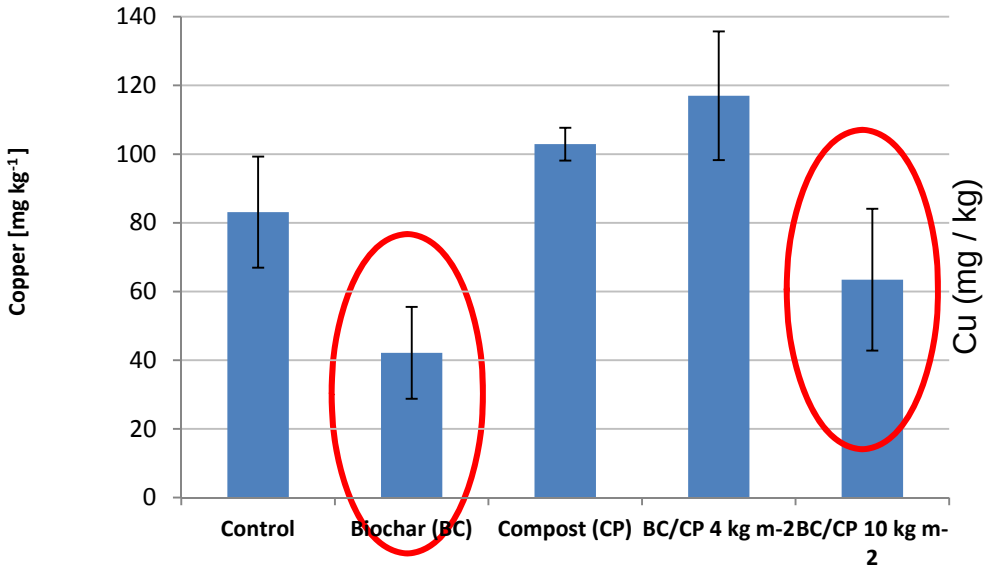
Decreases in Cu_{CaCl2} by high biochar additions

Same Cu_{total} concentrations

Reduction of Copper Uptake by Green Cover Plants

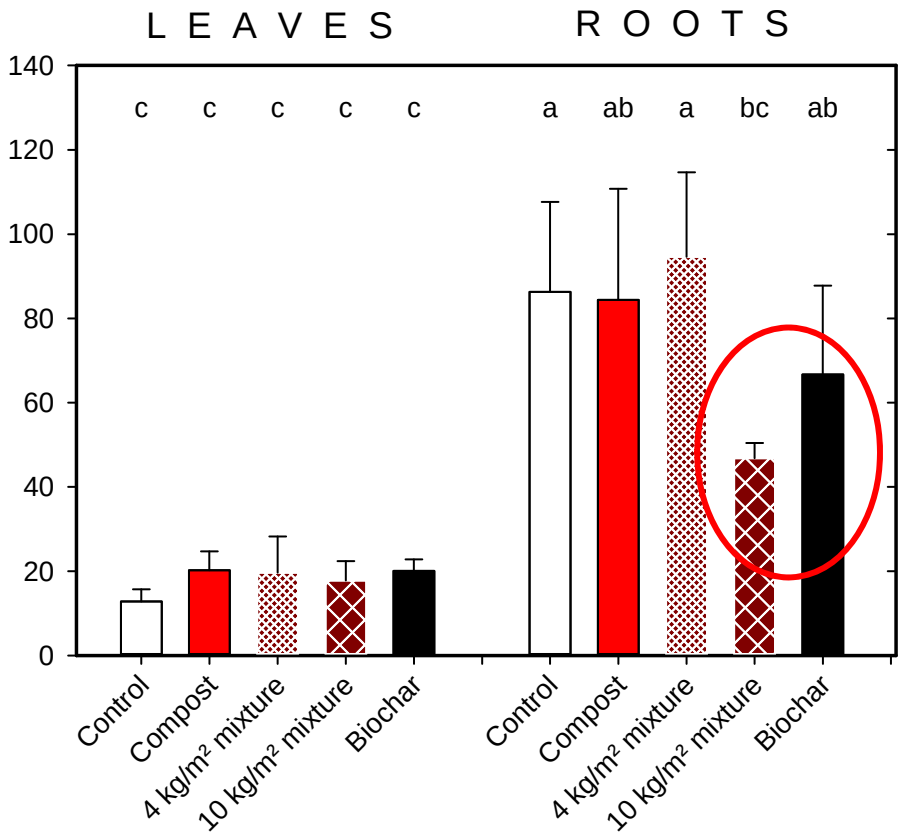
White clover

Copper in *Trifolium repens* roots



Ryegrass

Copper in green cover crops: *Lolium perenne*



Quellen: von Chamier, 2016; Mlinkov, 2016

SUMMARY AND CONCLUSIONS

- **Effects** of compost and biochar on Cu-stabilization are **soil-specific:**
  - **neutral soils:** no effect on exchangeable Cu
  - **acidic soils:** minor reduction (but less than lime)
- **Clearer effect on freshly added Cu** than on old contaminations
- Additives have more benefits for reducing the ecotoxicologically relevant **Cu^{2+} fraction**, but not the mobile fraction of total Cu
- **Compost** has a **mobilizing effect**, **biochar** has an **immobilizing effect** for Cu
- Biochar without compost or high doses of biochar/compost mixtures in the field can **reduce Cu uptake into the roots** of cover crops in the vineyard
- With respect to **Cu stabilization:** the **opposite effects of biochar and compost** may cancel each other out; pure biochar slightly positive
- **Other beneficial effects of compost and biochar remain unaffected**

Thank you
for listening!