The Relationship Between Soil Copper and Glomalin in Coffee Plantations in Tarrazú, Costa Rica

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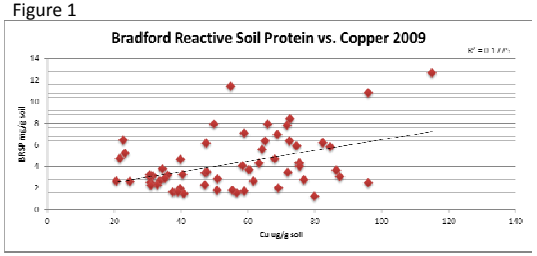
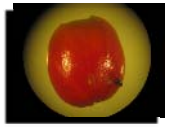
INTRODUCTION

Coffee in Costa Rica provides income for more than 78,000 farmers. In the Tarrazú region, the Costa Rican government has urged farmers to use copper based fungicides to combat a leaf pathogen *Mycena citricolor,* which can drastically decrease coffee yields, but this can cause soil copper to accumulate to toxic levels. Glomalin is a glycoprotein, produced by arbuscular mycorrhizal fungi associated with plant roots, which improves soil structure and can bind metals and reduce their bioavailability. In previous work, we found that copper concentrations in coffee fields averaged 56 ppm (21 min to 115 ppm max), potentially high enough to cause toxic effects to plants. This is well above background, reflecting many years of pesticide use. There was also a significant positive correlation between copper and glomalin (Fig. 1). Based on our preliminary results, we hypothesized that copper would be positively correlated with soil glomalin and soil organic matter, and that high copper levels in soils might stress coffee plants causing reduced yield.

Figure 1





METHODS

- Copper and other metals were assessed using an atomic absorption spectrometer and glomalin was assessed in heat-stable soil extracts using the Bradford test for total protein and an ELISA test for immunoreactive glomalin.
- A fanega is a measurement of coffee used in Costa Rica to quantify yield on a volume basis.

REFERENCES

Gonzalez-Chavez MC, Carrillo-Gonzalez R, Wright SF, Nichols KA. (2004) "The role of glomalin, a protein produced by arbuscular mycorrhizal fungi, in sequestering potentially toxic elements." Environ Pollut 130:317-323
Treseder KK, Turner KM. (2007) "Glomalin in Ecosystems" Soil Sci. Soc. Am. J. 71:1257-1266

ACKNOWLEDGEMENTS

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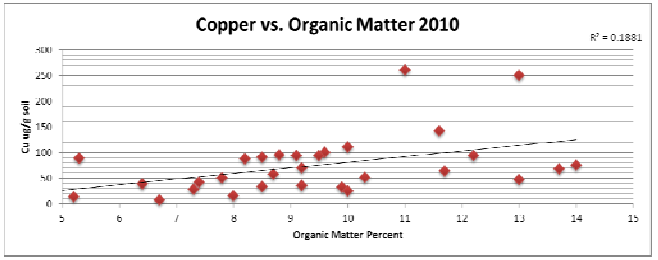
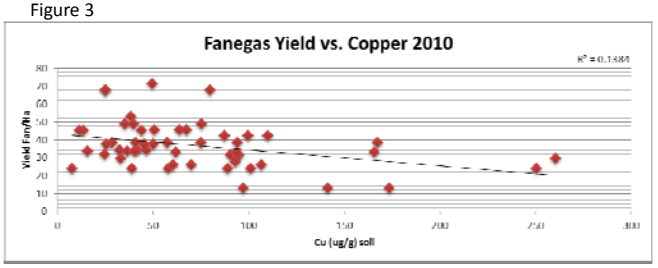
RESULTS

Figure 2



- There was no significant correlation between copper and glomalin.
- Copper was positively correlated with soil organic matter (Fig. 2)
- Copper was negatively correlated with coffee yield (Fig. 3)

Figure 3



SUMMARY TABLE		
	Regression Statistics	
	R Square	*P-value*
Yield Fan/Ha vs. Copper 2010	0.1384	0.0052
Copper vs. Organic Matter 2010	0.1881	0.0166

DISCUSSION

- We did not see the expected correlation between copper and glomalin, despite our preliminary results. In other studies, glomalin produced by mycorrhizal fungus has been observed to bind up to 4mg Cu per gram of protein (Gonzalez-Chavez et al. 2004).
- High concentrations of glomalin and organic matter are strongly related in soils (Treseder et. al 2007) but we found positive correlations between copper and organic matter but not directly between copper and glomalin.
- The correlation between copper and soil organic matter may be due to the ability of organic matter to complex with and retain copper after it is applied.
- The negative correlation between copper and coffee yield may reflect plant stress induced by metal toxicity in the soil. Spraying copper sulfate on coffee plantations could be causing an accumulation of copper in the soil, resulting in declining yield.
- Future research would include gathering additional soil samples for further copper and glomalin analysis. Copper sulfate application on farms can be gathered into a data set for use in building a GIS map showing glomalin correlations.

MANAGEMENT IMPLICATIONS

- Reducing the use of copper based fungicides on coffee plantations might reduce bio-toxicity and increase yields throughout Tarrazú region
- Addition of organic matter (for example, by adding mulch) may bind additional copper in the soil and prohibit it from accumulating in plants