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Copper nanoparticles and compounds impact agronomic and physiological parameters in cilantro (*Coriandrum sativum*)

Nubia Zuverza, PhD Student
The University of Texas at El Paso
Dr. Gardea-Torresdey's Research Group
March, 2015

- 19th largest city in the US
- Ranked as the safest large city in the US during the last three years

(Annual City Crime Rankings by CQ press)

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Copper nanoparticles and compounds impact agronomic and physiological parameters in cilantro (*Coriandrum sativum*)

Outline

- Introduction
- Materials
  - Cilantro
  - Copper products
- Procedure
  - Soil treatment
  - Plant growth and harvest
  - Sample preparation and analysis
- Results
  - Agronomic parameters
  - Nutritional value (physiological parameters)
- Summary

http://www.renaissanceherbs.com.au/system/0000/0167/08_31_52_944_coriander_Medium_.jpg

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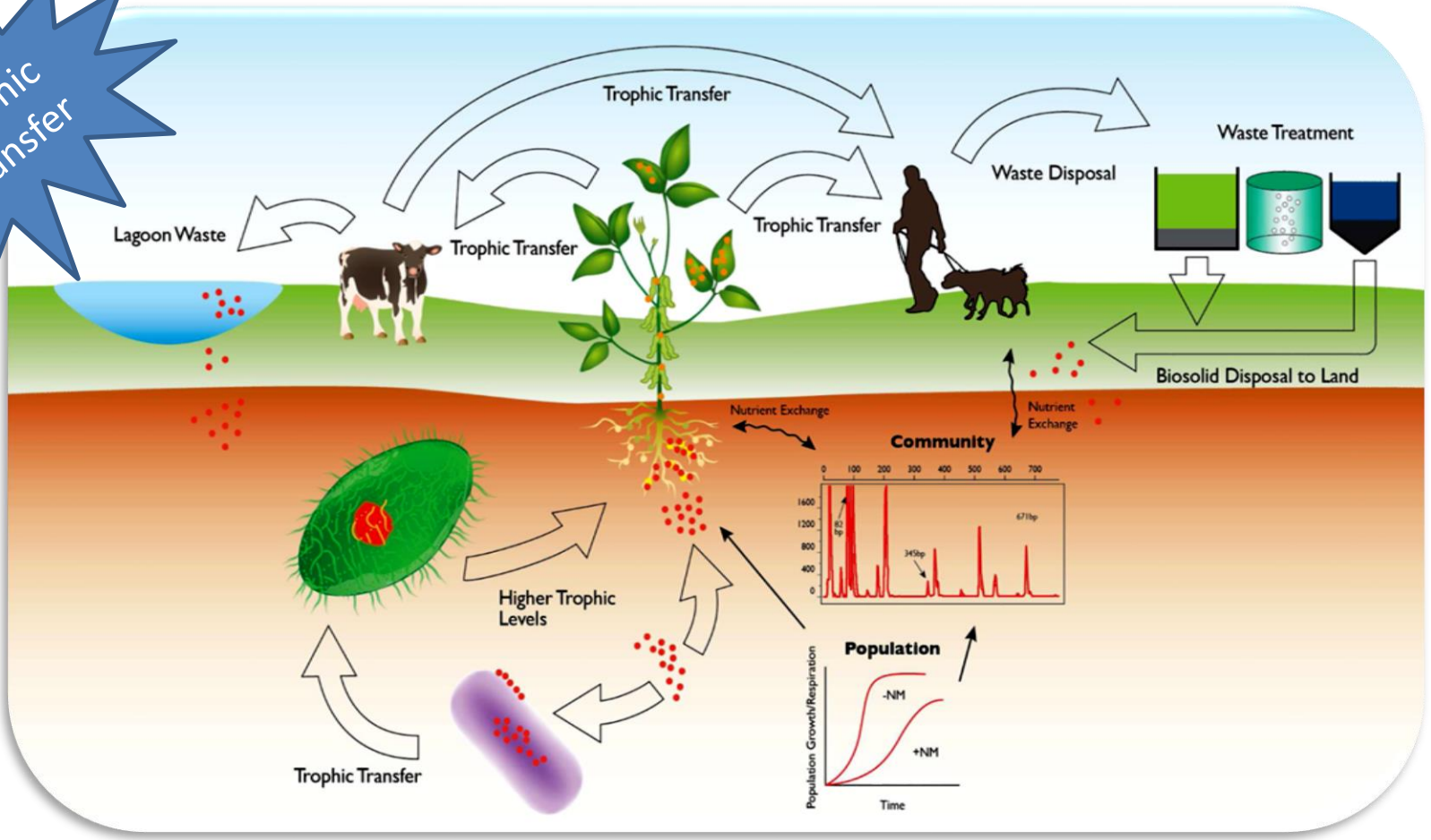
Fate of nanoparticles in the environment

Trophic transfer



Holden, P.A; Nisbet, R.M.; Lenihan, H.S.; Miller, R.J.; Cherr, G.N.; Schimel, J.P.; Gardea-Torresdey, J.L. *Accounts Chem. Res.* **2013**, 46, 813-822.

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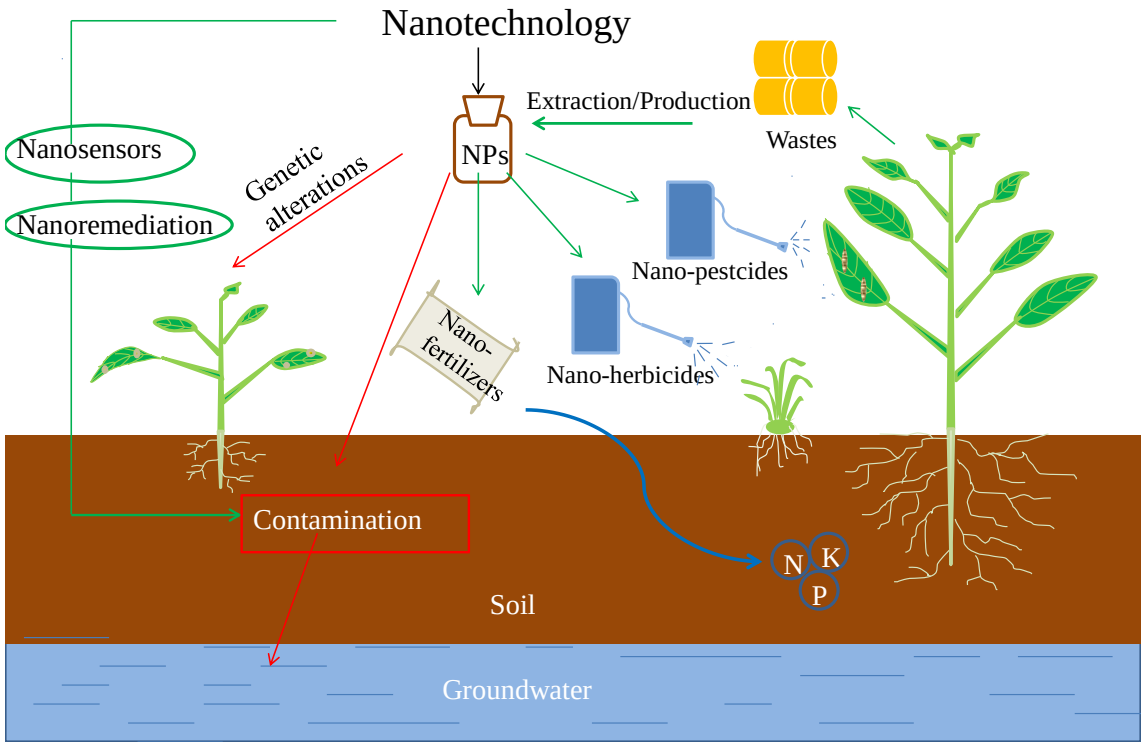
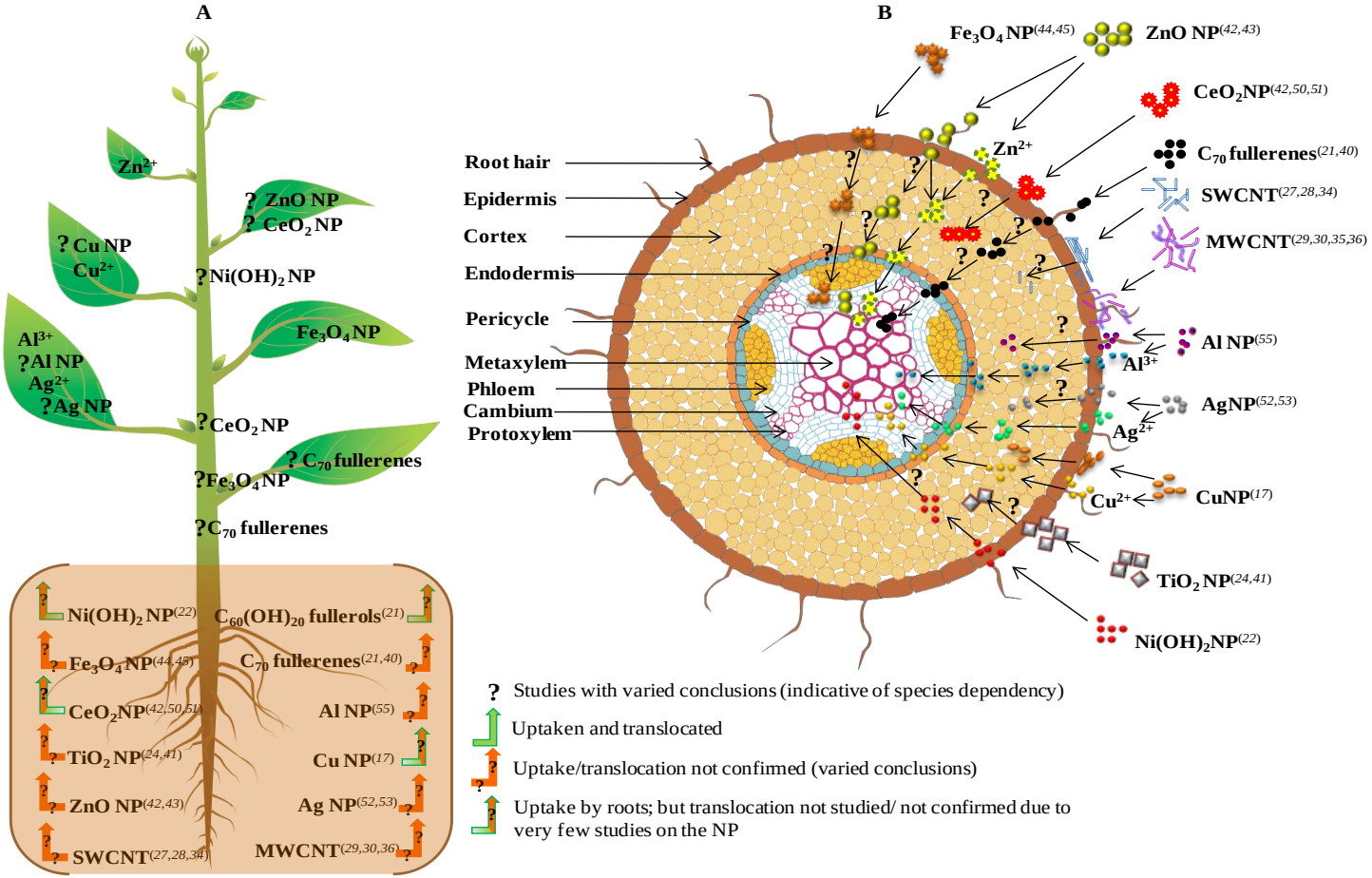
Use of nanomaterials in agricultural activities



Hong, J., Peralta-Videa, J.R., Gardea-Torresdey, J.L. 2013. Nanomaterials in agricultural production: benefits and possible threats? In: Sustainable Nanotechnology and the Environment: Advances and Achievements. Edited by Sharma, V. and Shamin, A.N., ACS Symposium Series Vol. 1124, 73-90 (DOI:10.1021/bk-2013-1124).

ENMs and Plants



Rico, C. M.; Majumdar, S.; Duarte-Gardea, M.; Peralta-Videa, J. R.; Gardea-Torresdey, J. L. Interaction of nanoparticles with edible plants and their possible implications in the food chain. *J. Agric. Food Chem.* **2011**, *59*, 3485-3498.

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FOR IMMEDIATE RELEASE

ACS News Service Weekly PressPac: June 1, 2011

Safety of nanoparticles in food crops is still unclear

Scientists are reporting a huge gap in knowledge about the effects of nanoparticles on corn, tomatoes, rice and other food crops.

Credit: iStock

"Interaction of Nanoparticles with Edible Plants and Their Possible Implications in the Food Chain"

Journal of Agricultural and Food Chemistry

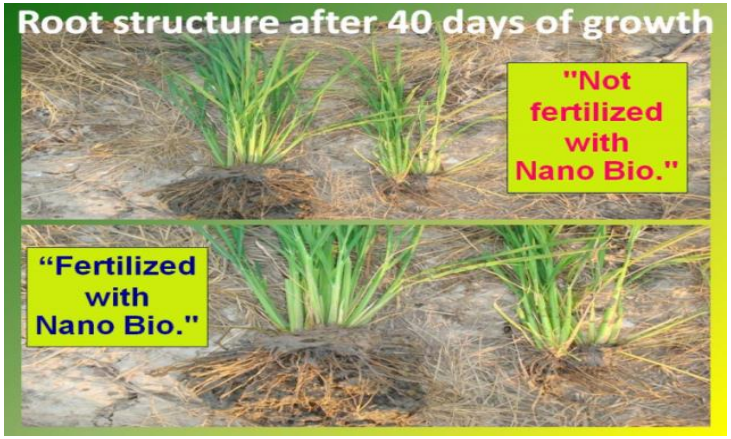
With the curtain about to rise on a much-anticipated new era of "nanoagriculture" — using nanotechnology to boost the productivity of plants for food, fuel, and other uses — scientists are reporting a huge gap in knowledge about the effects of nanoparticles on corn, tomatoes, rice and other food crops. Their article appears in ACS' *Journal of Agricultural and Food Chemistry*.

Jorge Gardea-Torresdey and colleagues at The University of Texas at El Paso, a co- investigator for the NSF/EPA University of California Center for Environmental Implications of Nanotechnology, note that nanoparticles, which are 1/50,000th the width of a human hair, are used in products ranging from medicines to cosmetics. The particles also could end up in the environment, settling in the soil, especially as fertilizers, growth enhancers and other nanoagricultural products hit the market. Some plants can take-up and accumulate nanoparticles. But it is unclear whether this poses a problem for plants or for the animals (like humans) that eat them. So, the researchers sorted through the scientific literature looking for evidence to settle the safety question.

Nanotechnology in agriculture

“GRAND ENTRY TO THE FOODCHAIN”

Nanopesticide



Nanofertilizers

Nano Bio Marketing 2011. http://nanobiomarketing.com/en/ contents/view/knowledge/101

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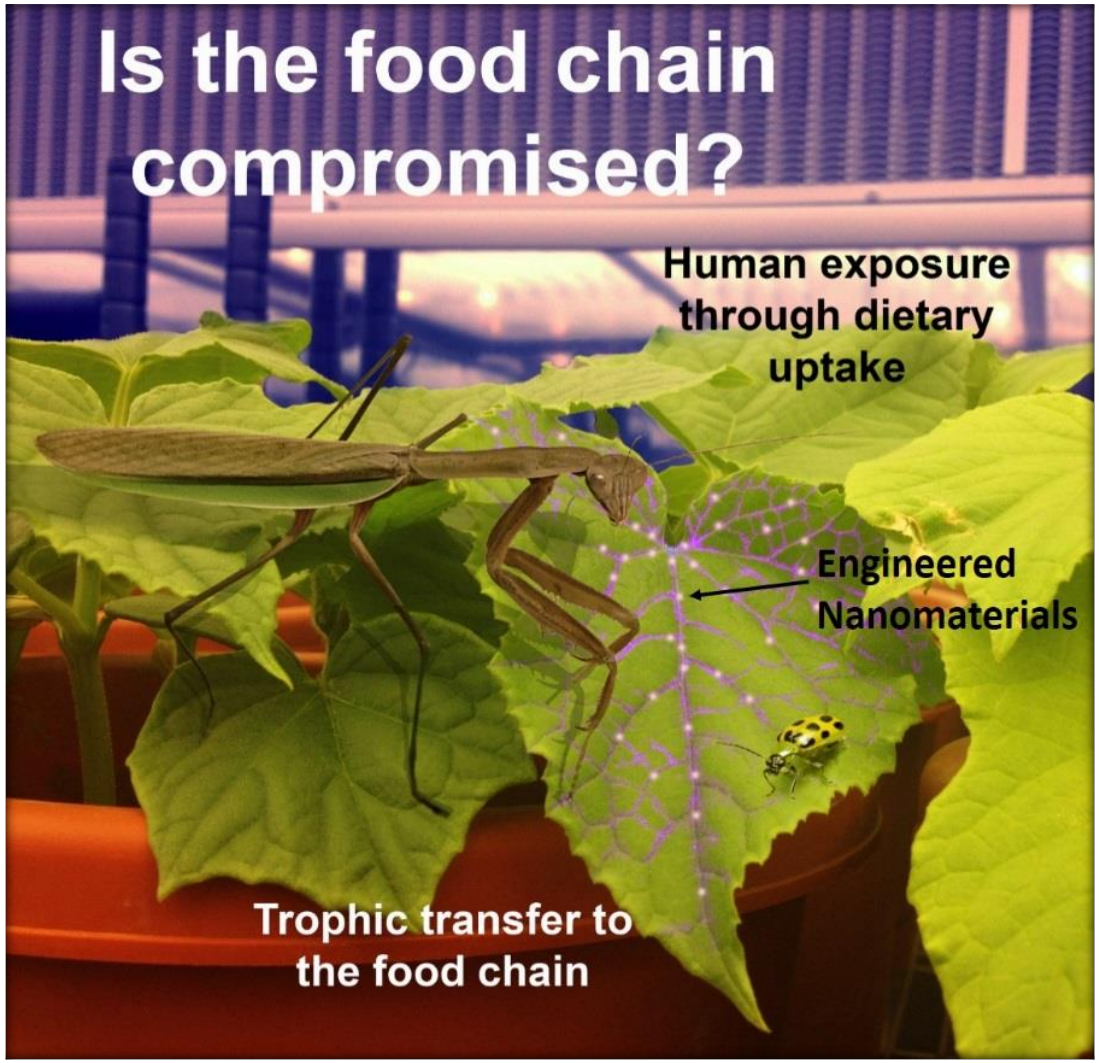

Gardea-Torresdey, J. L.; Rico, C. M.; White, J.C. Trophic Transfer, Transformation, and Impact of Engineered Nanomaterials in Terrestrial. *Environ. Sci. Technol.***2014**, *48*, 2526-2540.

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Copper NPs and compounds

- $Cu(OH)_2$ CuPRO 2005
  - 53.8% copper hydroxide
- $Cu(OH)_2$ Kocide 3000
  - 46.1% copper hydroxide
- $CuCl_2$

- Cu NPs, 40nm
- Cu bulk, <60 µm
- CuO NPs, <50nm
- CuO bulk, <5µm

Cilantro

http://clatl.com/omnivore/archives/2010/04/16/cilantro-its-not-just-for-food-snobs

http://pixgood.com/rabbit-eating-lettuce.html

http://www.grubstreet.com/2012/01/foreign_cinemas_gayle_pirie_lo.html

http://www.roadfood.com/Forums/What-IS-a-taco-m145993.aspx

http://cocinaycomparte.com/recetas/sopa-de-albondigas-con-arroz-y-cilantro

- *Coriandrum sativum*
  - *(cilantro)*
- Cu into food chain – spices
- Herb, culinary spice
- Eaten fresh
- Antioxidant properties

http://jessfuel.com/wp-content/uploads/2013/04/RoastedTomatilloSalsaVerde13.jpg

https://kathleeniscookinginmexico.files.wordpress.com/2010/03/chipotle-fish-soup-3.jpg

http://ajillofalltrades.blogspot.com/2011/09/best-salsa-recipe.html

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Cilantro exposed to copper soil

Suspension preparation

Suspension sonication

Soil + Cu

Cu Concentration in soil:

0 ppm (control)

20 ppm

80 ppm

Procedure – plant growth & tissue harvest

30 days growth

Harvest

Tissue washing

Measurement

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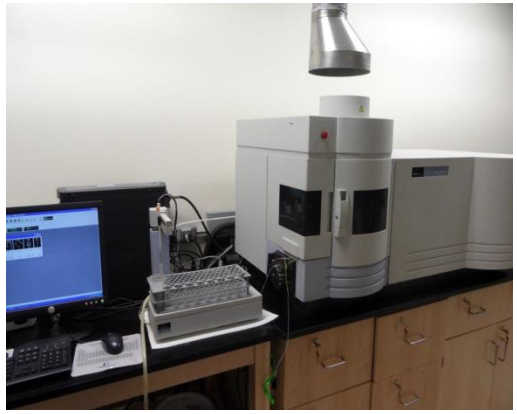
Sample analysis

Samples dried at 70 °C

Sample weight = 100 mg

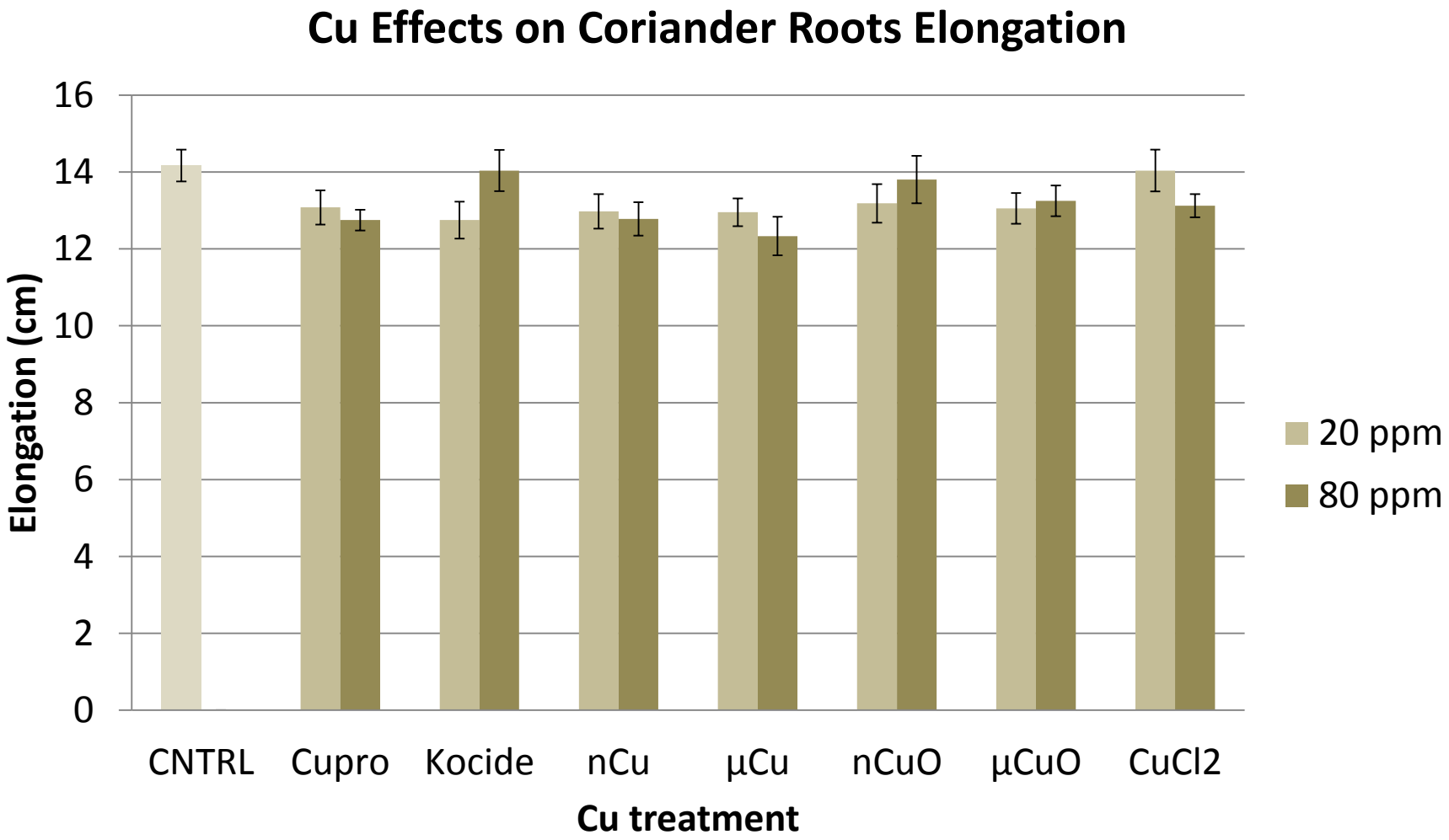
Microwave oven

Sample digestion



ICP-OES analysis

Agronomic results



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Paper in preparation

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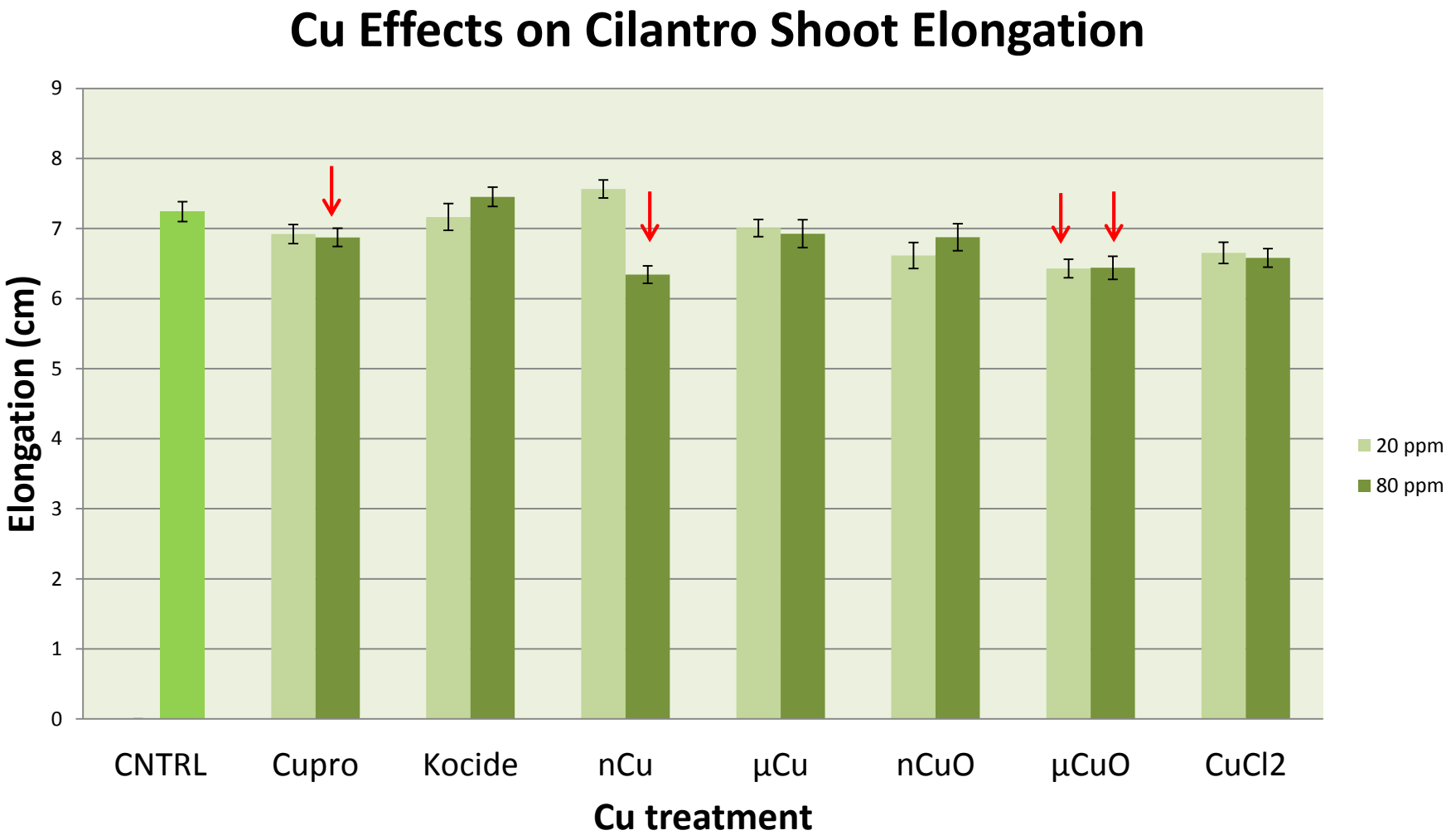

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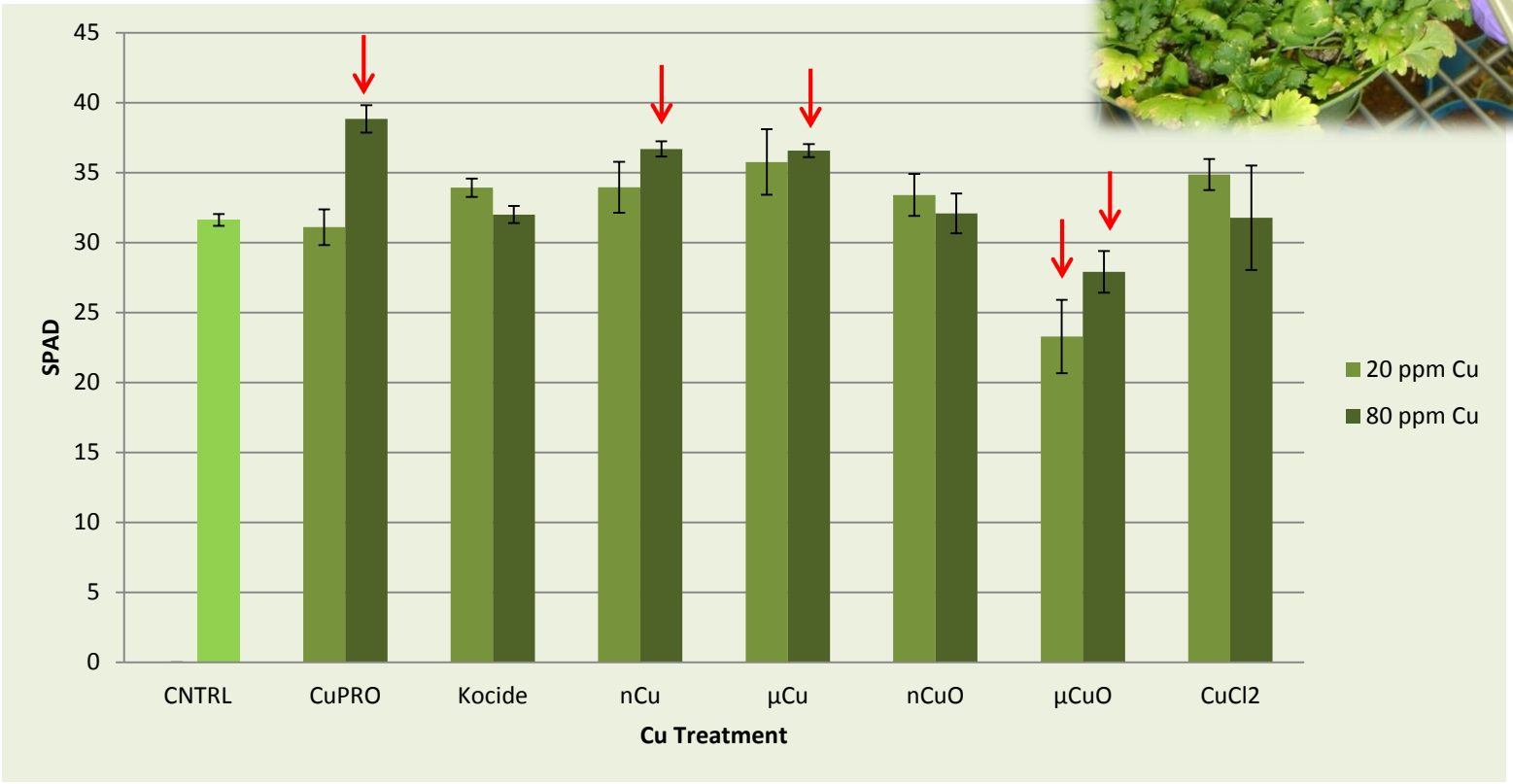
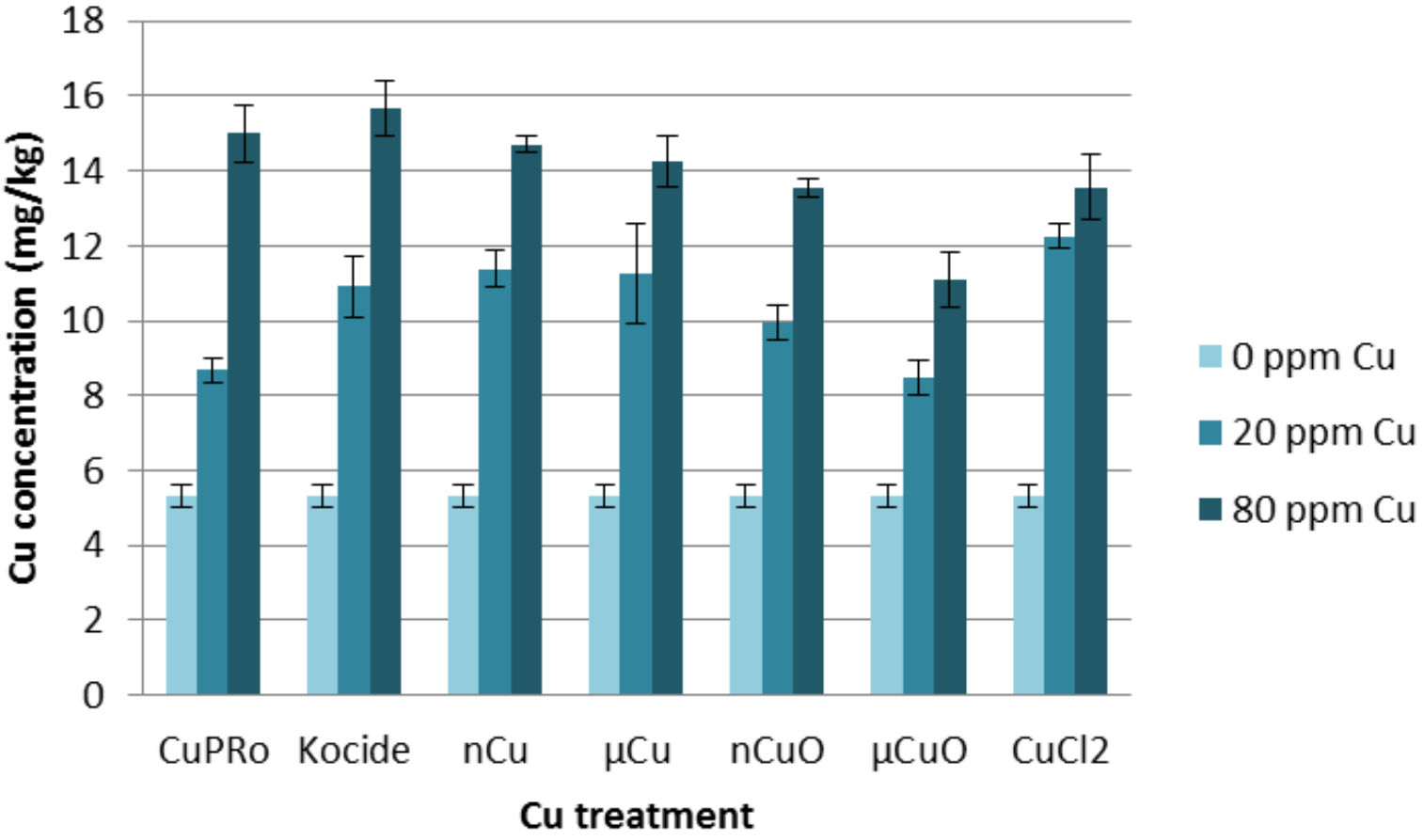
Cu Effects on Cilantro Chlorophyll



Paper in preparation

Copper concentration in cilantro shoots



Paper in preparation

20ppm Cu effects in cilantro shoots nutritional value

	B	Zn	Mn	Ca	P	S	Mg
CuPRO			+	+	-		
Kocide				-	-	+	-
nCu			+	+	-	-	
µCu		-			-		-
nCuO	+				-	-	-
µCuO				-	-	+	-
$CuCl_2$			+	+	-		

Paper in preparation

80ppm Cu effects in cilantro shoots nutritional value

	B	Zn	Mn	Ca	P	S	Mg
CuPRO			+	+	-		
Kocide				-	-		-
nCu	+				-		
µCu	+	-		-	-		
nCuO	+				-	-	-
µCuO		+		-	-		-
$CuCl_2$			+		-	-	-

Paper in preparation

Summary

		CuPRO		Kocide		nCu		µCu		nCuO		µCuO		$CuCl_2$	
		20	80	20	80	20	80	20	80	20	80	20	80	20	80
Shoot length							↓					↓	↓		
Chlorophyll content			↑				↑					↓	↓		
Nutrients	Mg	↑		↓	↓			↓		↓			↓		↓
	P	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
	S			↑						↓		↑			↓
	Ca	↑	↑	↓	↓	↑			↓				↓	↑	
	B						↑	↑		↑		↑			
	Mn		↑			↑								↑	↑
	Zn								↓				↓		

- Agronomic parameters in cilantro were mostly affected by 80 ppm nCu and both 20 and 80 ppm bulk CuO
- Chlorophyll content was increased by 80ppm CuPRO and nCu; decreased by both concentrations of bulk CuO
- Nutritional value was affected by all copper compounds

Paper in preparation

Acknowledgements

- CEIN NSF-EPA # EF0830117.
- USDA-UPRM grant # 2008-38422-19138.
- National Science Foundation (NSF) CHE-0840525.
- Dudley Family for Endowed Chair.
- LERR and STAR Grants of the University of Texas System.
- NIH BBRC 2G12MD007592
- Science and Technology Mexican National Council (CONACyT)

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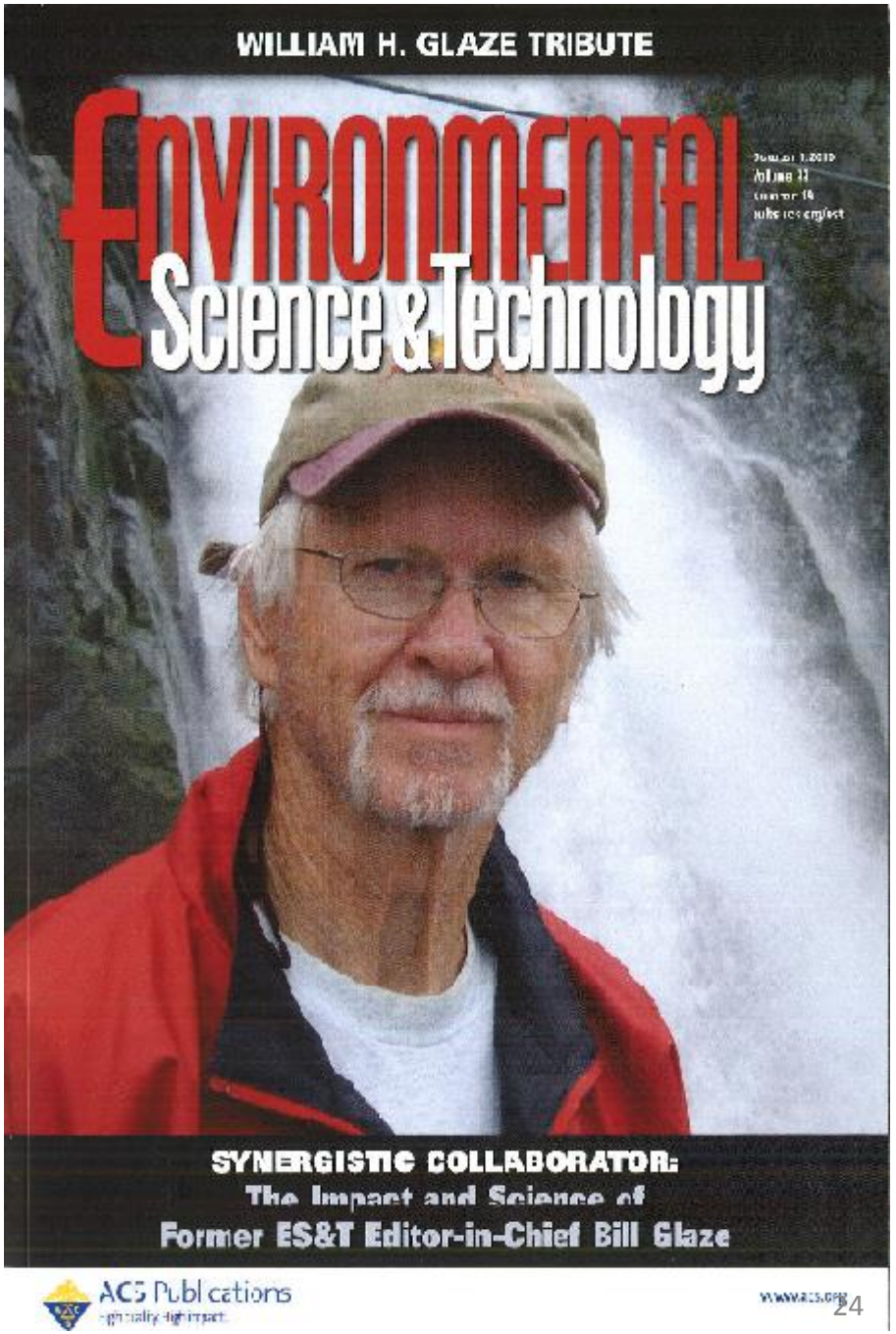
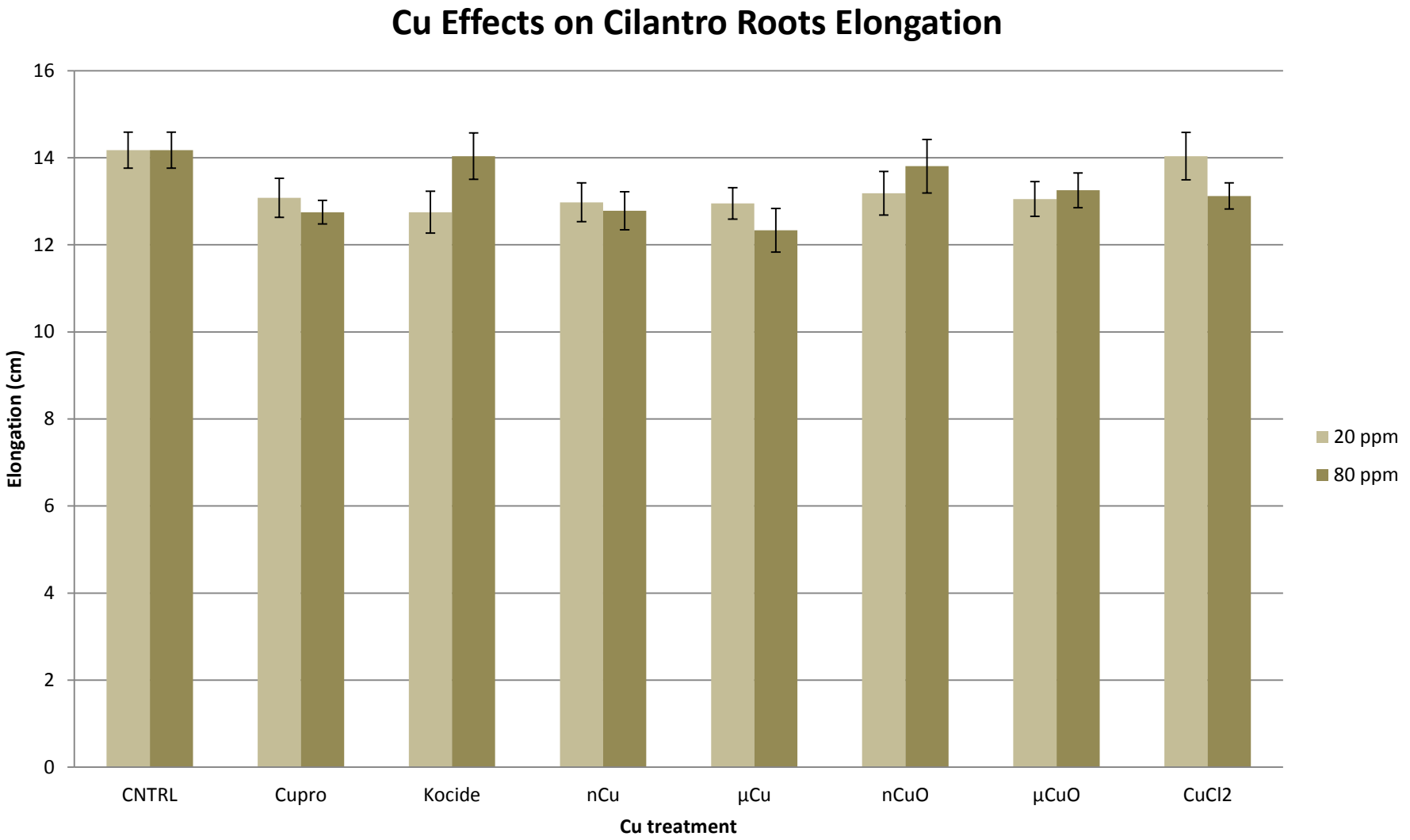
Gardea-Torresdey"s Research Group (Fall 2014)
http://www.ssslogic.com/gardea

In Memory
Prof. William “Bill” Glaze
ES&T Editor-in-Chief
1988-2002
“A Mentor, and a Friend”
Passed away December 17, 2014
“A 21st century pioneer in environmental science and technology.”




Thank you!
Questions?
SNO 2014 student awardees

Physiological results

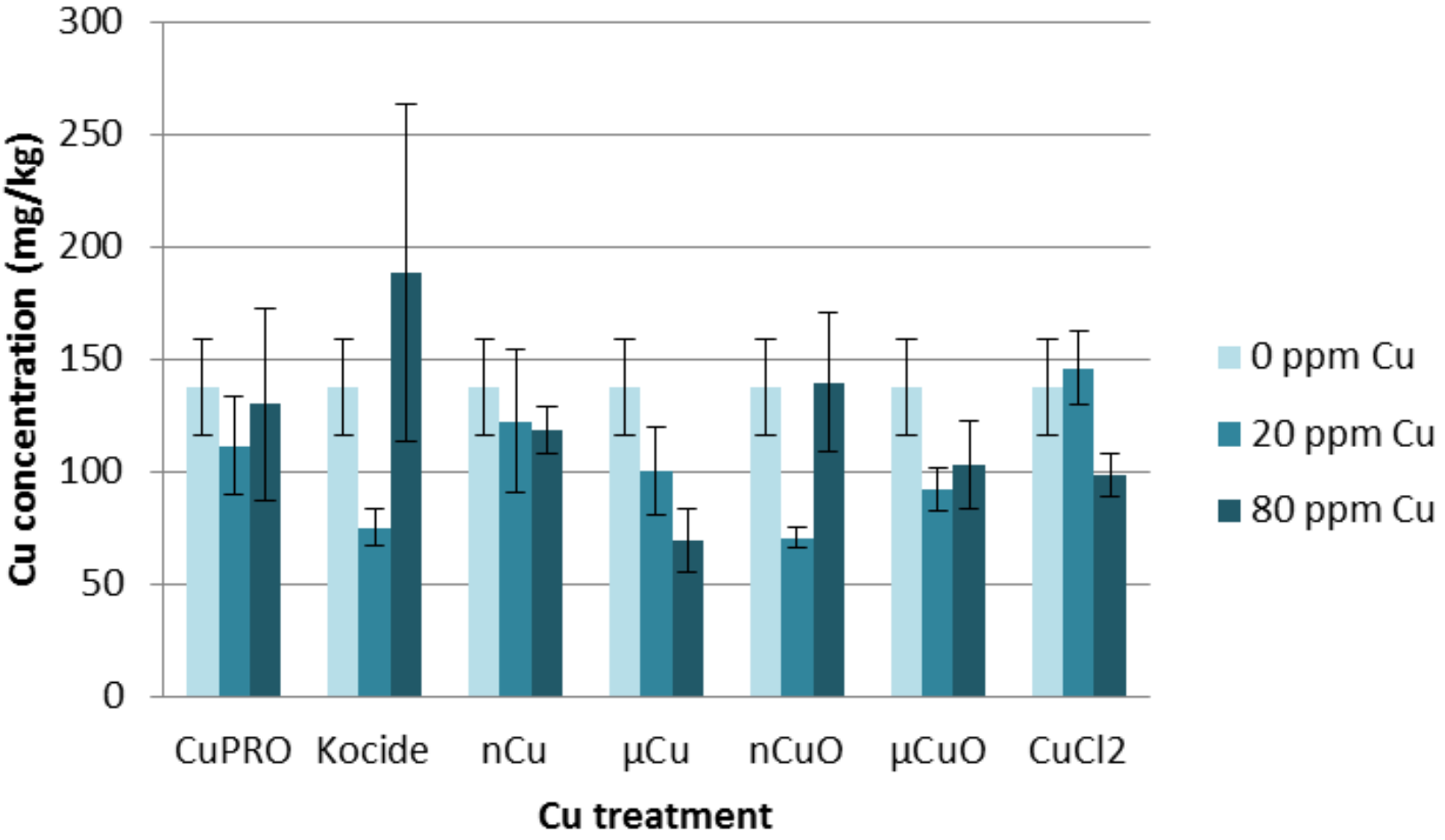


UC CEIN Center for Environmental Implications of Nanotechnology

Paper in preparation

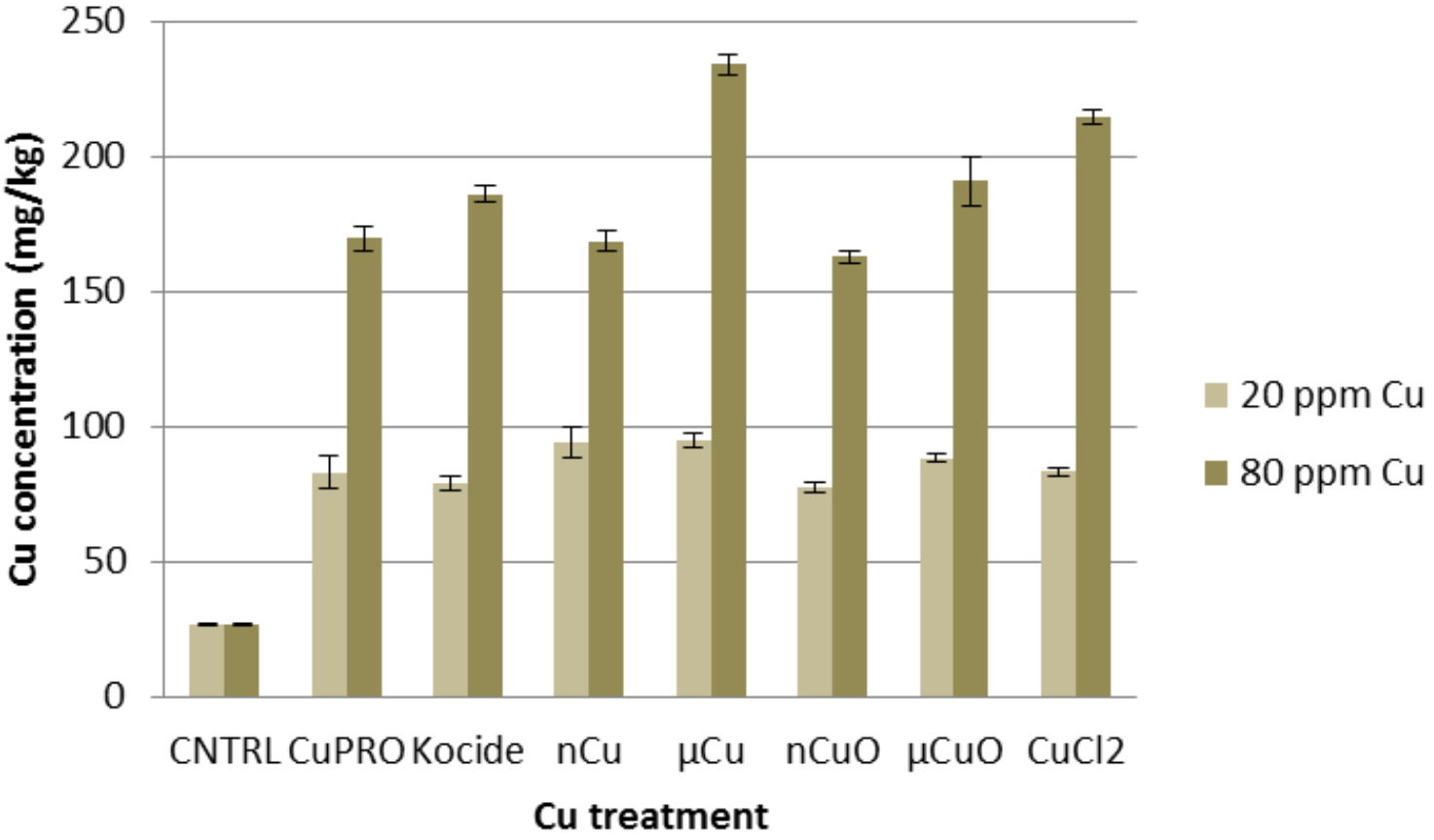
UTEP

Copper uptake by cilantro roots



Paper in preparation

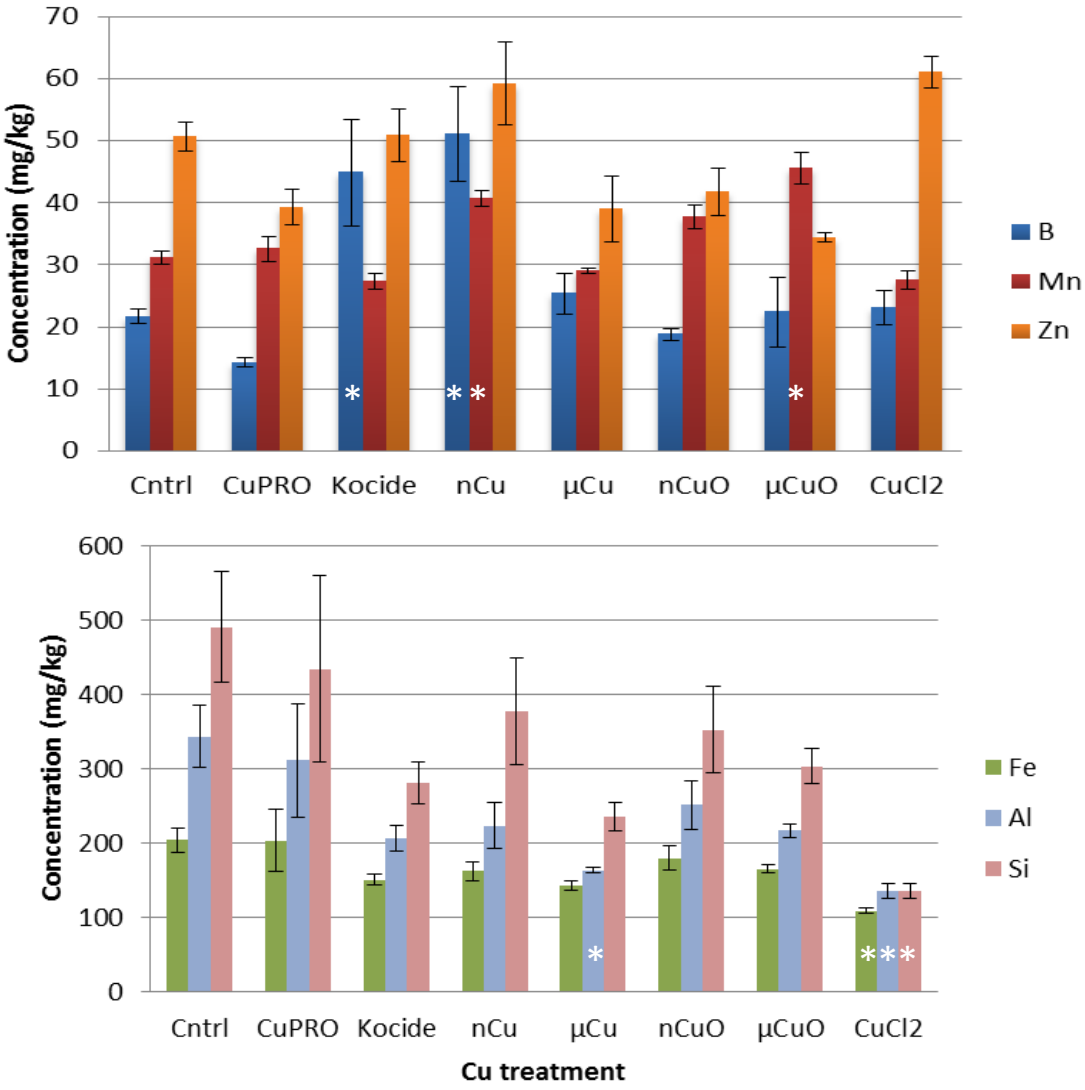
Copper concentration in soil



Paper in preparation

Agronomical results

Nutrients concentration in cilantro roots exposed to 20ppm copper compounds



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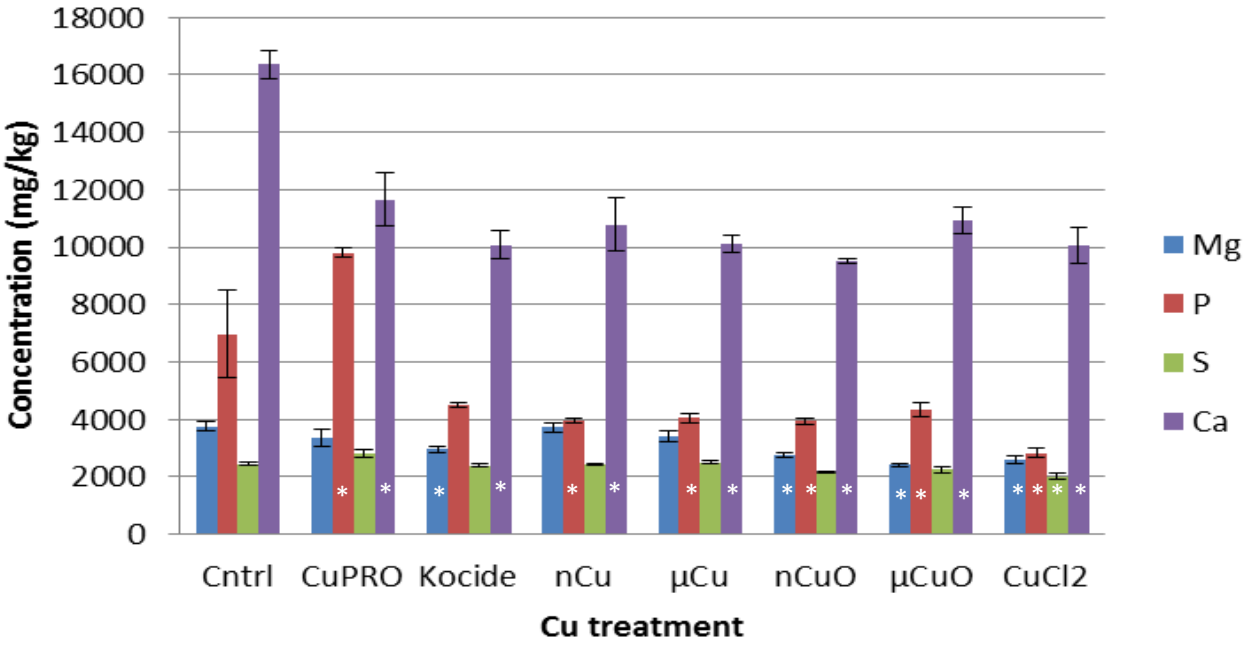
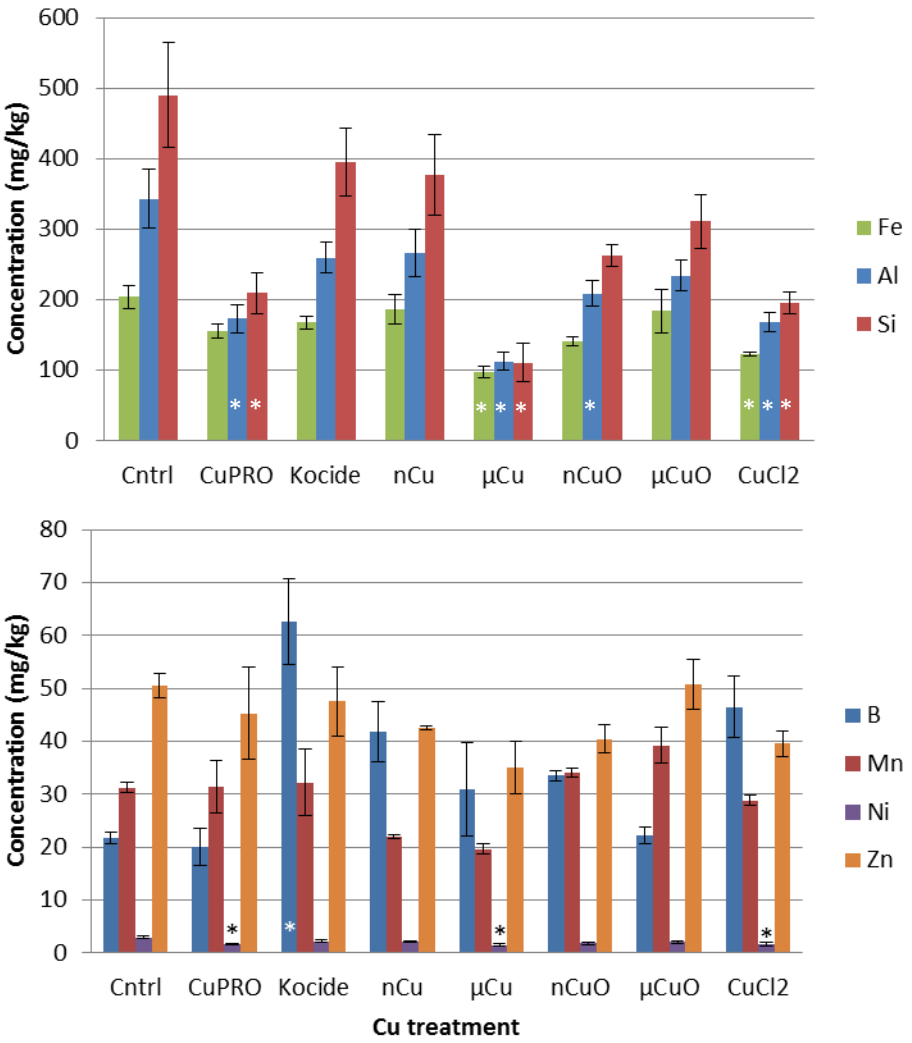


Paper in preparation

Agronomical results

Nutrients concentration in cilantro roots exposed to 80ppm copper compounds



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Paper in preparation

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Agronomical results

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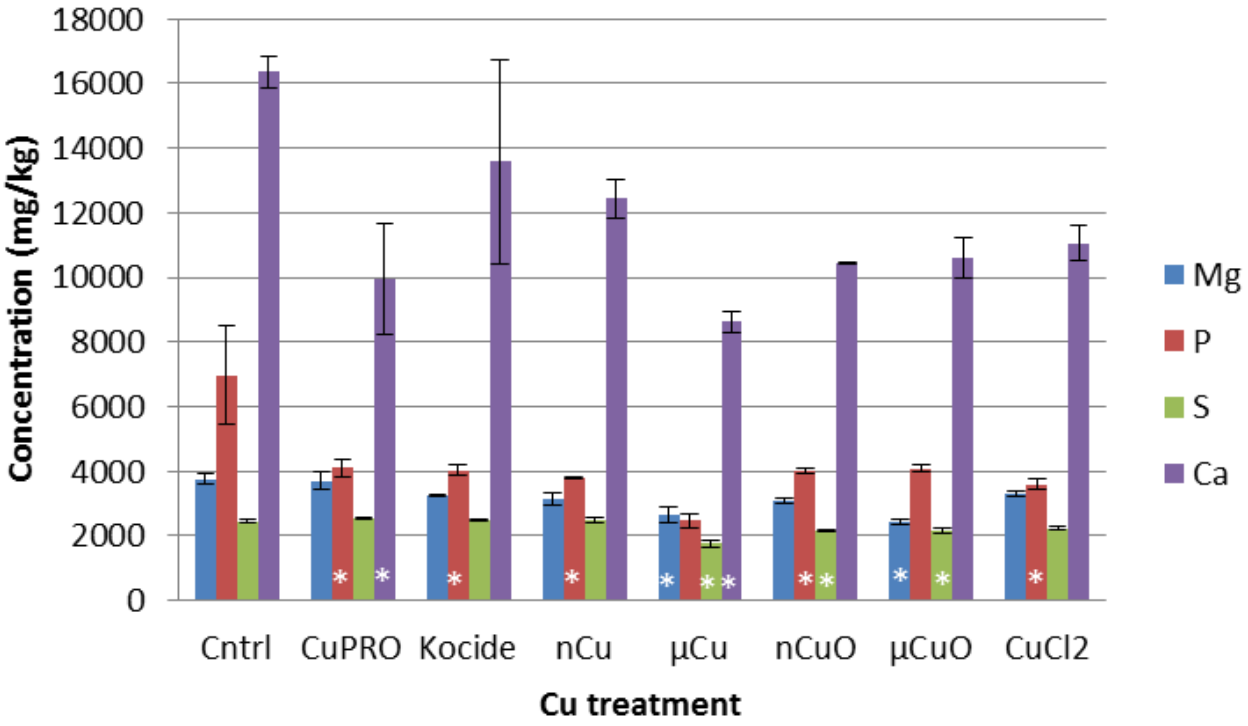
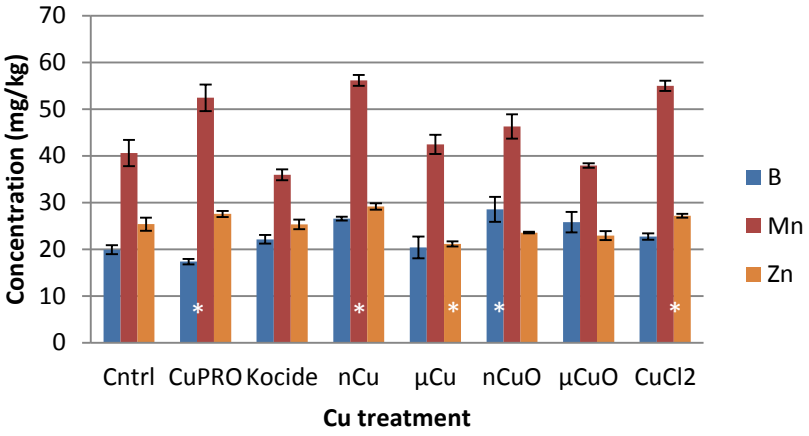
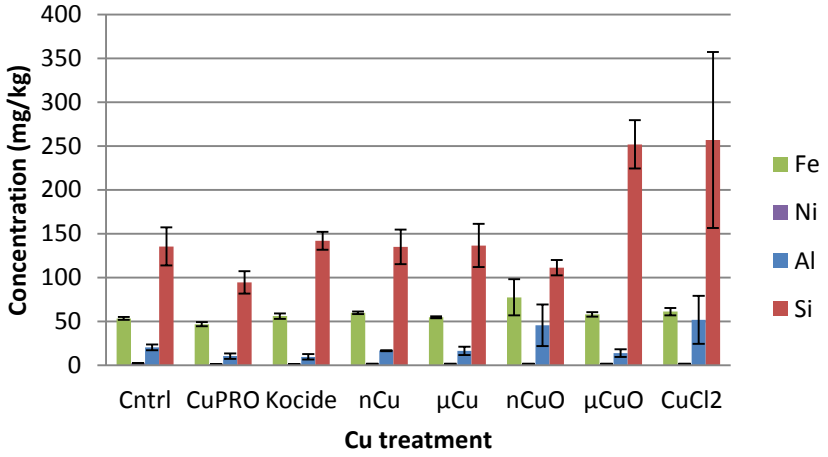
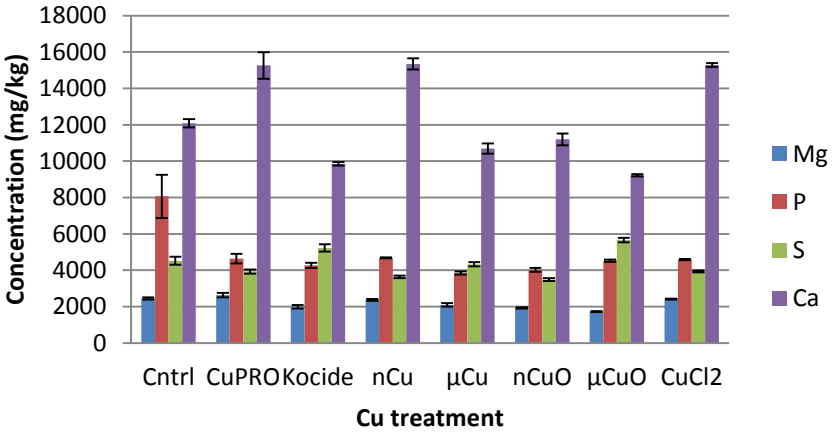


Paper in preparation

20ppm Cu effects in cilantro shoots nutrients



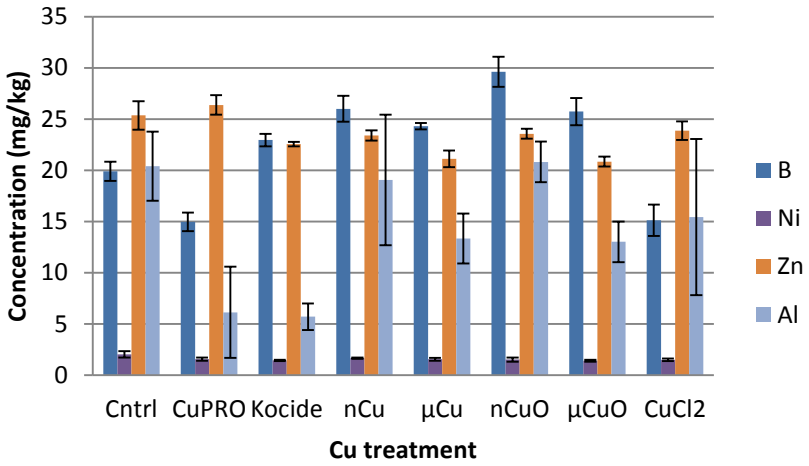


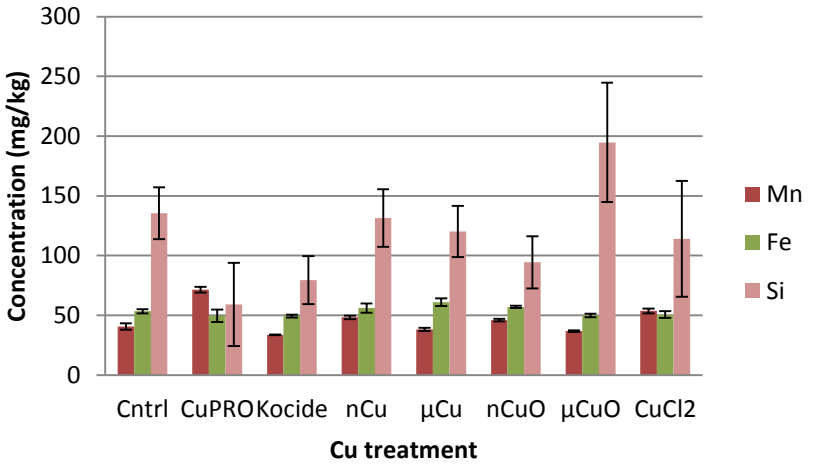


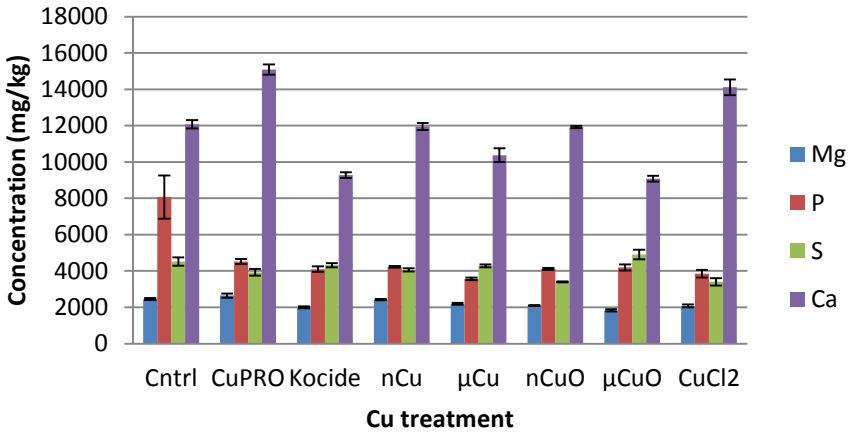
	Increases	Decreases
CuPRO	Mn, Ca	P
Kocide	S	Ca, Mg, P
nCu	Mn, Ca	S, P
µCu		Zn, Mg, P
nCuO	B	S, Mg, P
µCuO	S	Ca, Mg, P
CuCl2	Mn, Ca	P

Physiological results

80ppm Cu effects in cilantro shoots nutrients







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µCuO		Zn, Mg, Ca, P
CuCl2	Mn	Mg, S, P

Paper in preparation