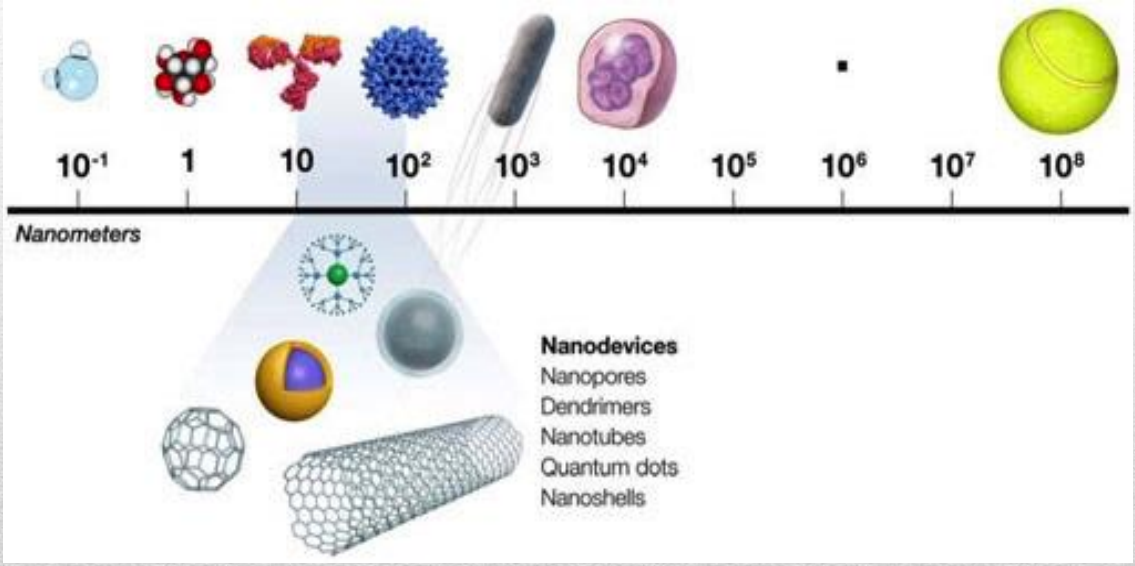
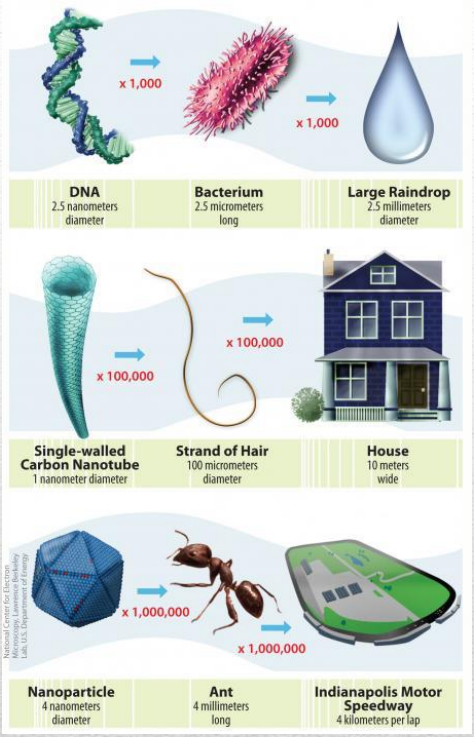
Uptake and Biochemical Effects of Copper Nanoparticle Exposure to Grey Zucchini (*Cucurbita pepo*)

Carlos Tamez, MS
Environmental Science and Engineering PhD Program
University of Texas at El Paso

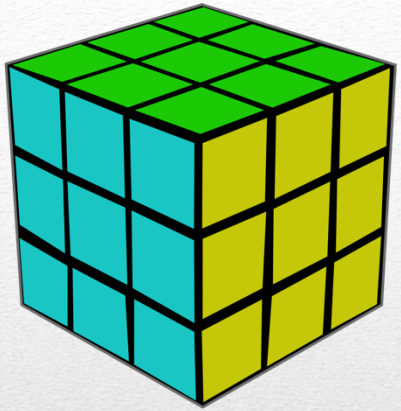
Nanoparticle – materials with at least two dimensions between 1 and 100 nm.





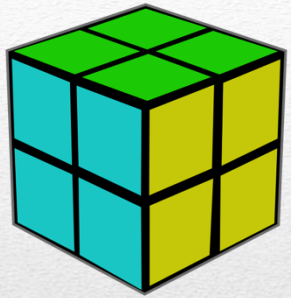
Introduction

Nano Scale Visualized



sides = 3
surface = 3^2 x 6 = 54
volume = 3^3 = 27

surface/volume = 2



sides = 2
surface = 2^2 x 6 = 24
volume = 2^3 = 8

surface/volume = 3

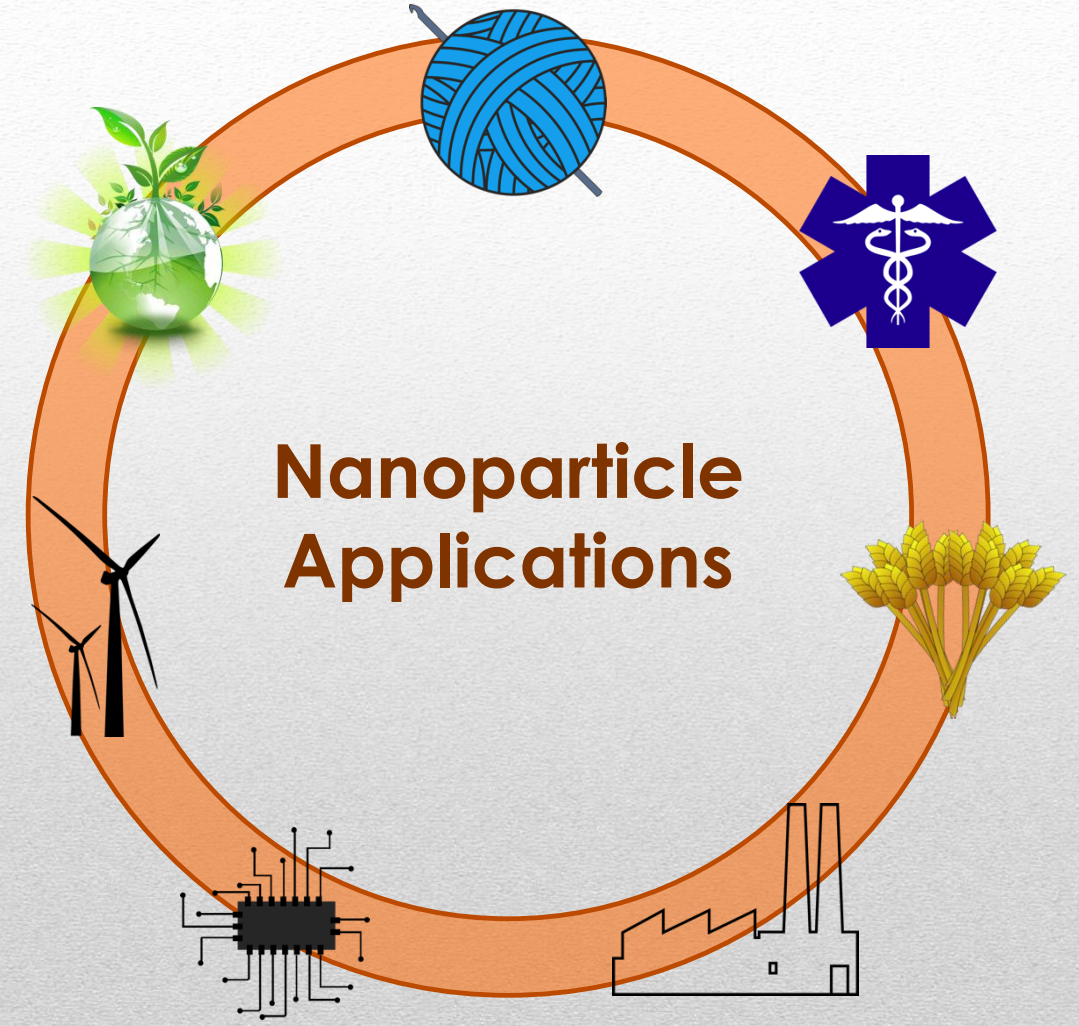
sides = 1
surface = 1^2 x 6 = 6
volume = 1^3 = 1

surface/volume = 6

Introduction

Increased Surface Area to Volume

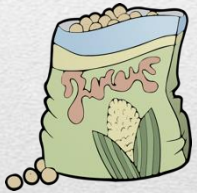
http://bit.ly/2z4M15Q


Nanoparticle
Applications

Holden, Patricia A. et al. (2016)

Anti-fouling paints on boats and ships

Copper based inks on printed circuit boards



Antimicrobial coatings on food packaging

Lumber preservative in pressure treated woods

Increasing interest in the uses of nano-sized pesticides and fertilizers

Introduction

Copper Nanoparticle Applications

NP	Plant	Experiment Type	Results	Reference
CuO	Yellow Squash	hydroponics	root length ↓ biomass ↓	(Stampoulis, Sinha, White 2009)
CuO	Duckweed	solution	plant growth ↓	(Perreault et al. 2010)
CuO	Waterweed	solution	phytotoxicity	(Johnson et al. 2011)
CuO	Waterweed	solution	oxidative stress ↓ photosynthesis ↓	(Nekrasova et al. 2011)
CuO	Cucumber	hydroponic	seedling biomass ↓	(Kim, Lee, Lee 2012)
CuO	Maize	hydroponic	growth ↓	(Wang et al. 2012)
Cu	Yellow Squash	hydroponic	biomass ↓	(Musante and White 2012)
CuO	Wheat	sand	shoot length ↓ root length ↓ biomass ↑	(Dimkpa et al. 2012) (Dimkpa et al. 2013)
CuO	Buckweat	3 day germination	root length ↓ seedling biomass ↓	(Lee et al. 2013)
CuO	Rice	14 day germination	germination ↓ oxidative stress ↑	(Shaw and Hossain 2013)
Cu/CuO	Lettuce	hydroponic	chlorophyll ↓ root length ↓ biomass ↓	(Trujillo-Reyes et al. 2014)
CuO	Lettuce/Alfalfa	hydroponic	growth ↓ stress ↓	(Hong et al. 2015)
CuO	Carrots	sand	no observable effects	(Ebbs et al. 2016)
CuO	Sweet Potato	Soil, maturity	biomass ↓	(Bradfield et al. 2017)

Cucurbita pepo

- Grey Zucchini
  - Variety of summer squash
  - Consumed worldwide
  - Domestic production, 2.6×10^{11} kg (all varieties)


http://bit.ly/1kXOpQu


http://bit.ly/1QFoDwP


http://bit.ly/2yP0Zwe

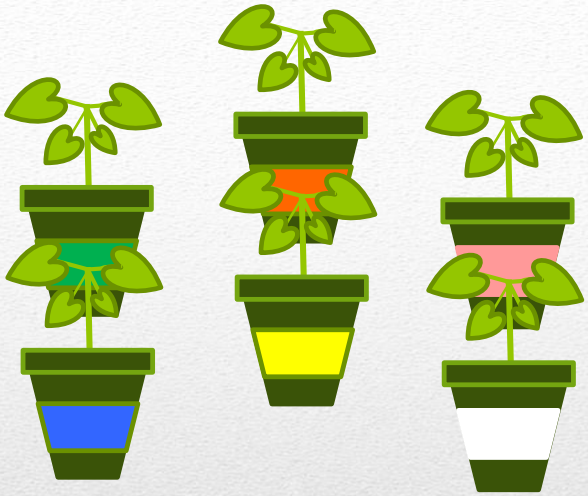

http://bit.ly/2y4byHs

Potential for human exposure through edible tissues

METHODS

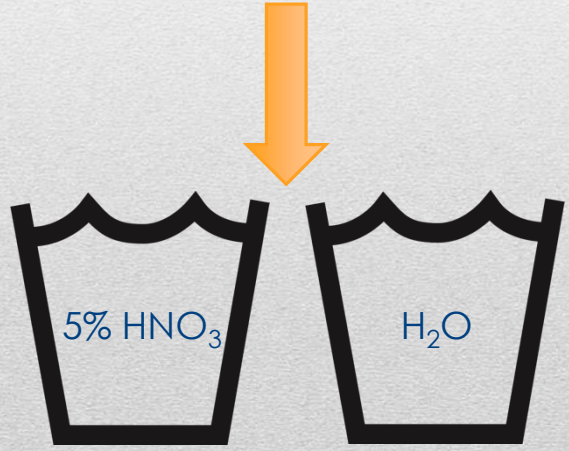
Mesocosm Experiments

- Native soil amended with Miracle-Gro
- Soil treated with a suspension of:
  - Kocide 3000 (46.1% $Cu(OH)_2$)
  - *n*CuO
  - bulk CuO
  - Cu NP
  - $CuCl_2$

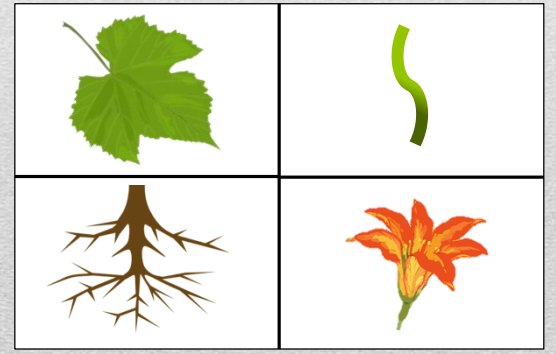


Tissue Harvest

Collect Measurements

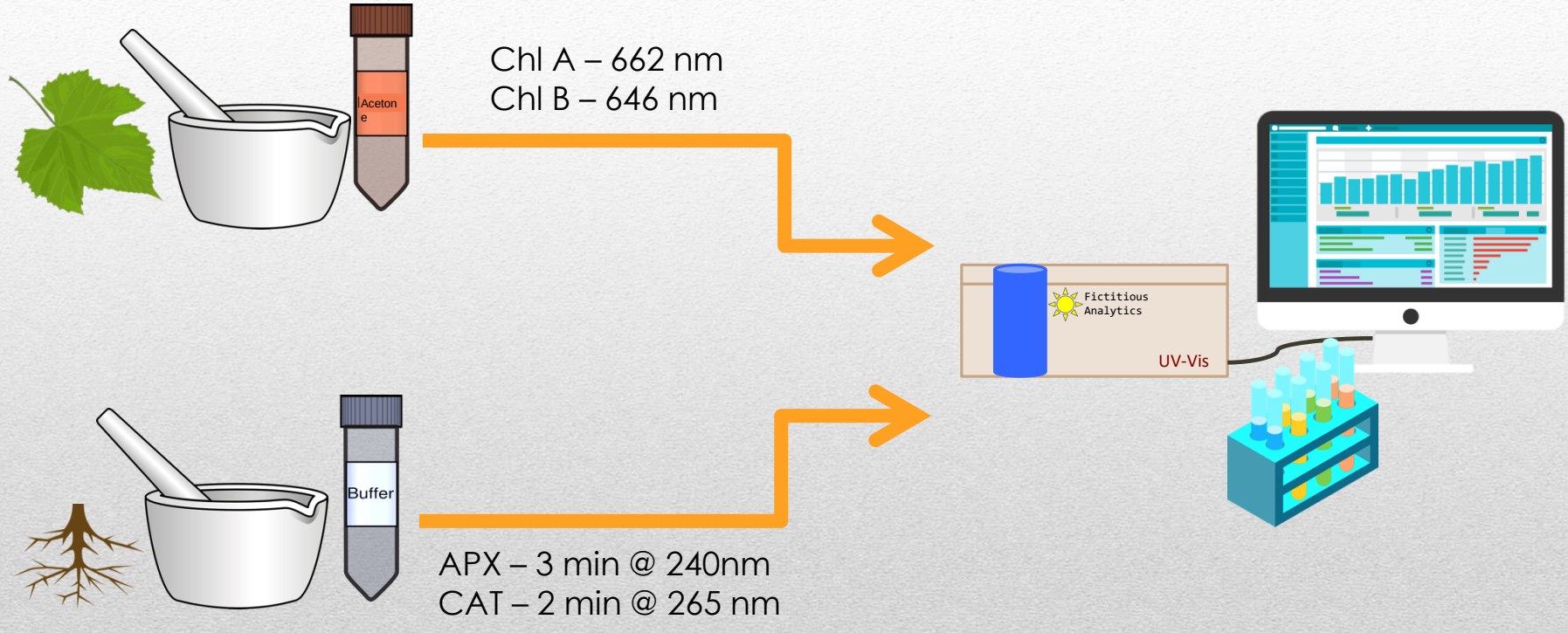


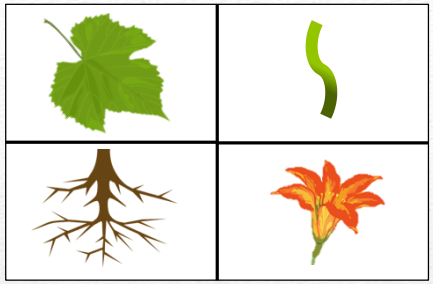
Tissue Washing



Tissue Separation

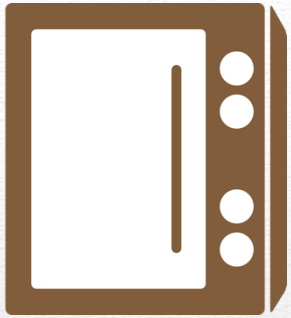
Fresh Tissue Analysis

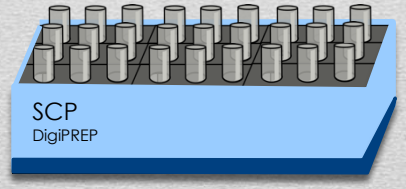




70°C

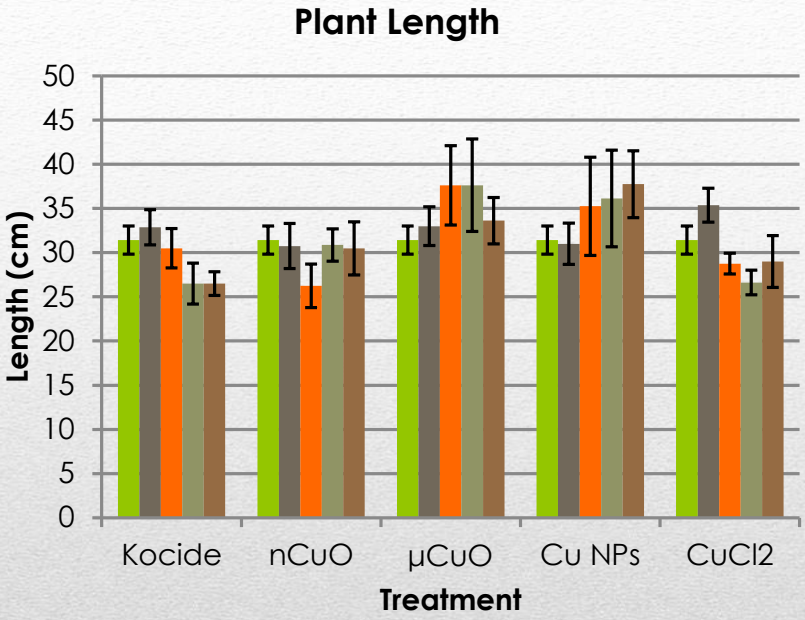
72 h

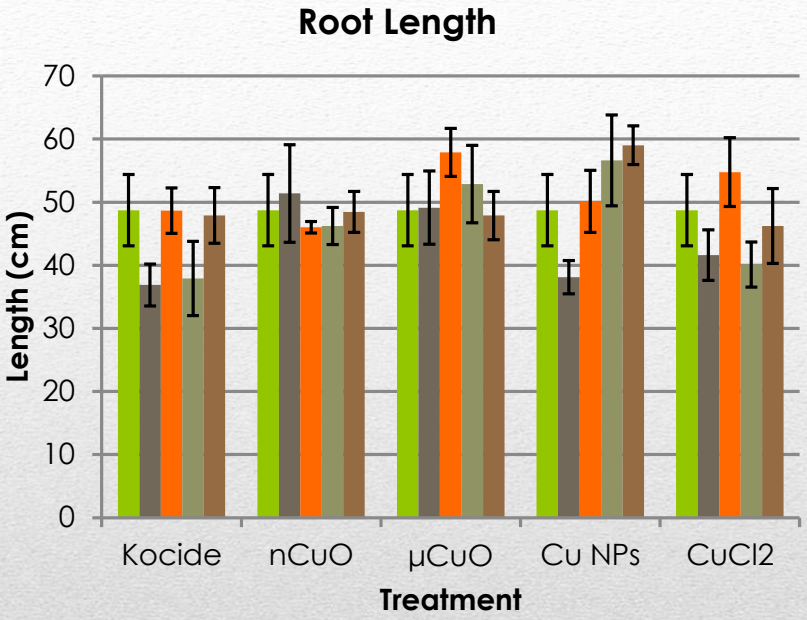




45 min @ 115°C

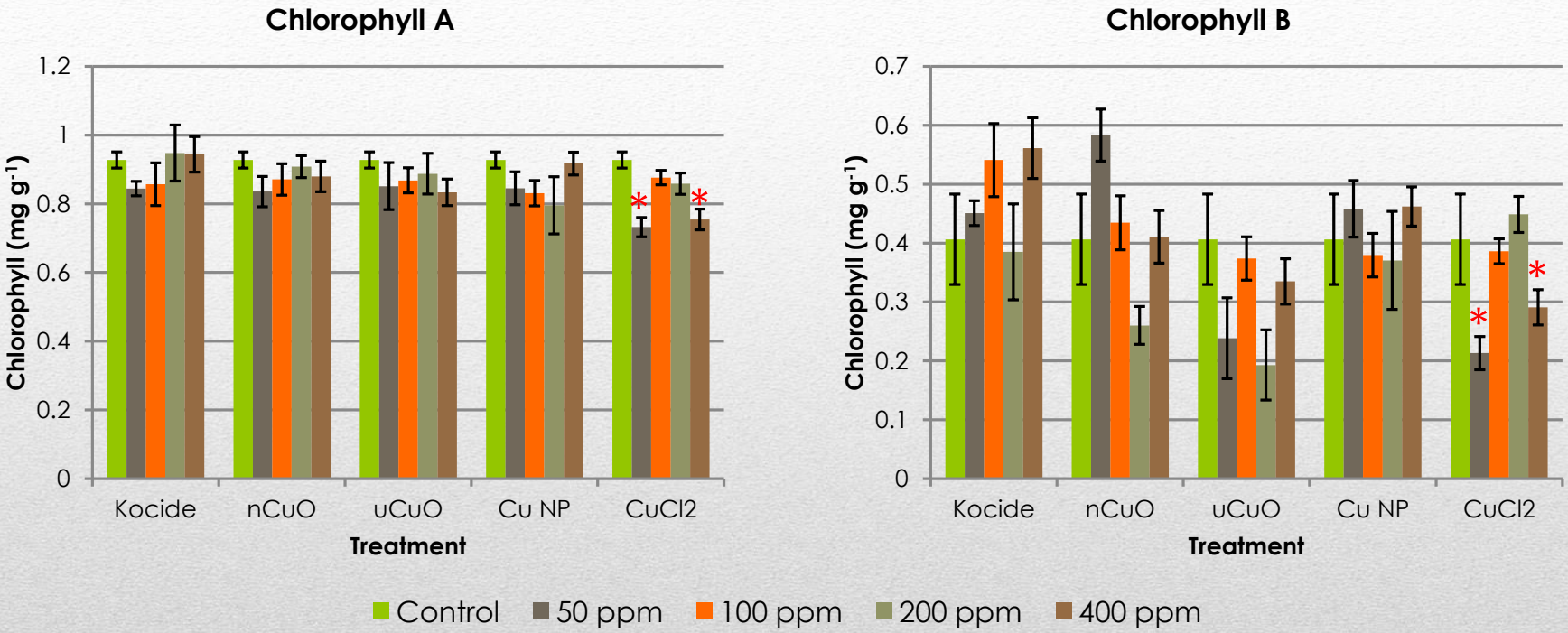
RESULTS


Plant Length
Length (cm)
50
45
40
35
30
25
20
15
10
5
0
Kocide
nCuO
µCuO
Cu NPs
CuCl2
Treatment

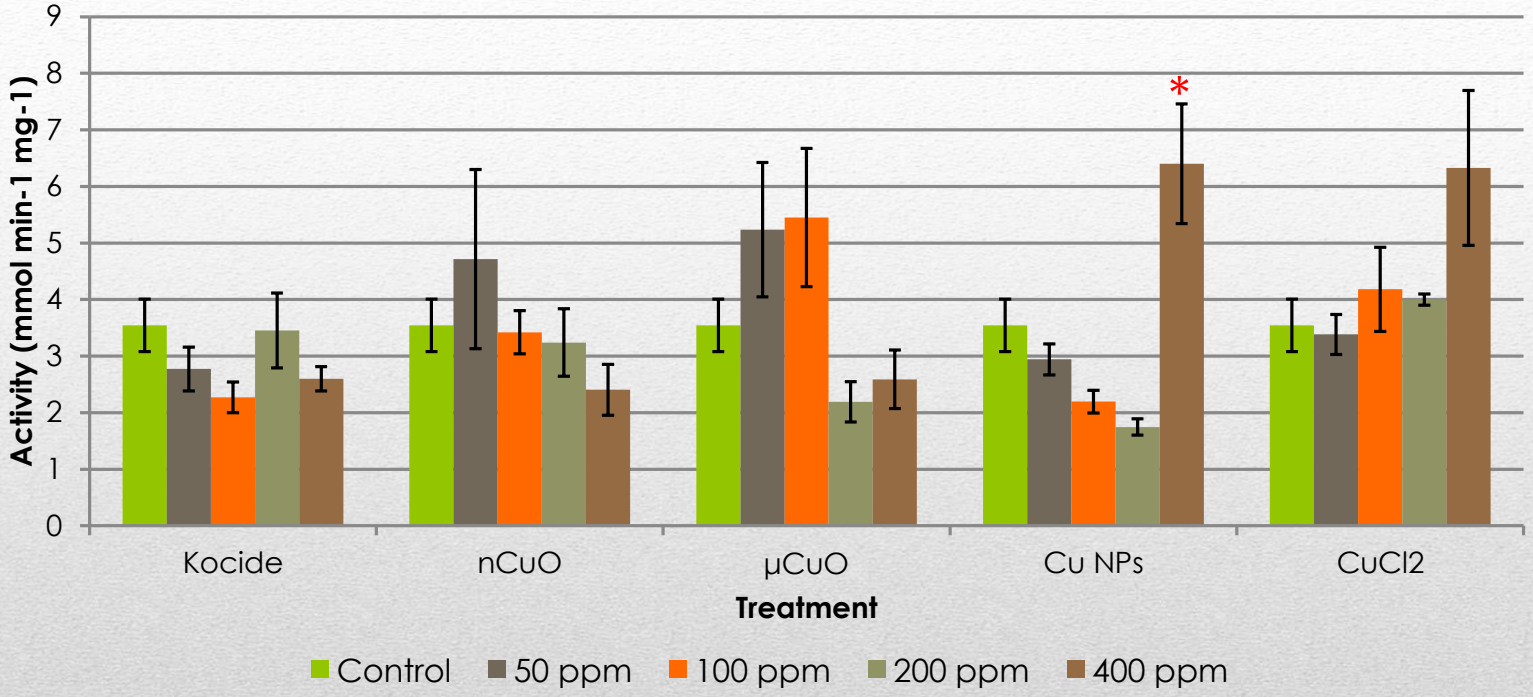

Root Length
Length (cm)
70
60
50
40
30
20
10
0
Kocide
nCuO
µCuO
Cu NPs
CuCl2
Treatment


Control
50 ppm
100 ppm
200 ppm
400 ppm

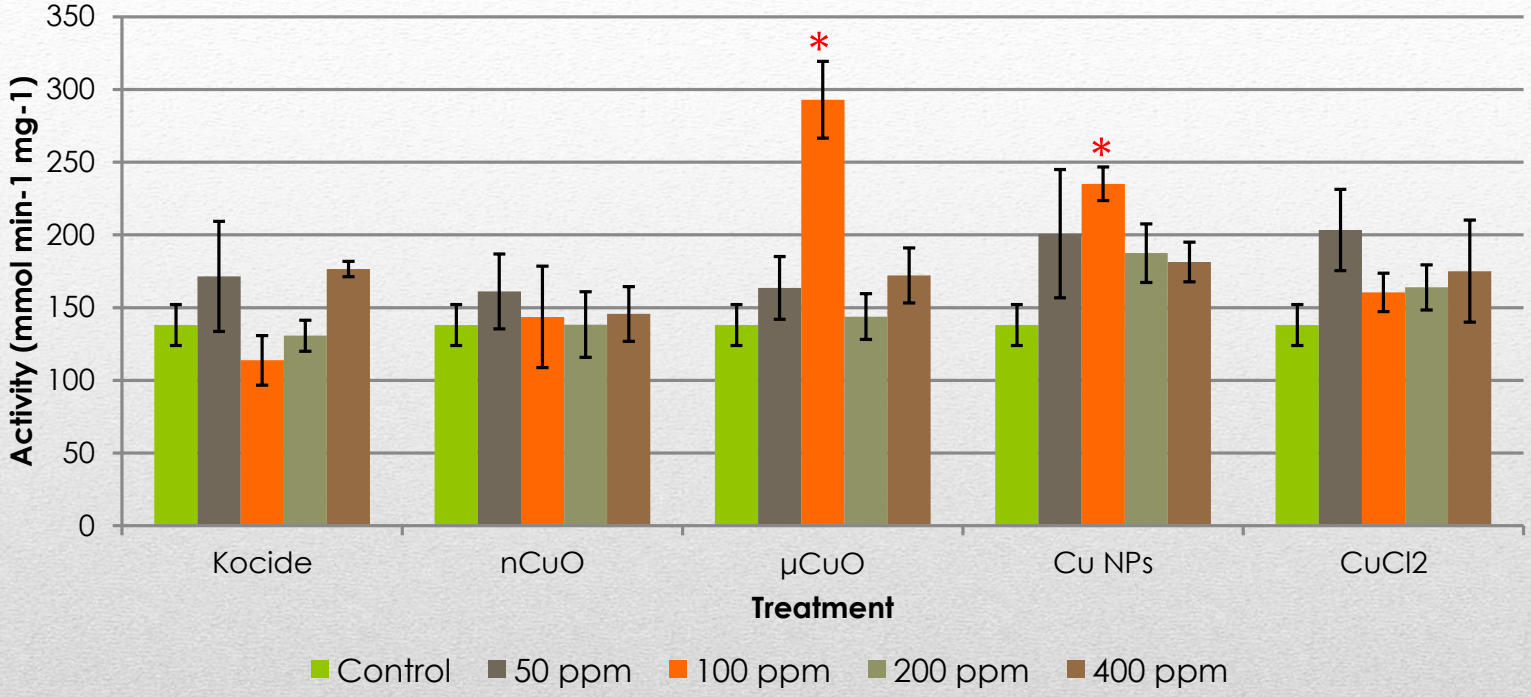
Agronomics



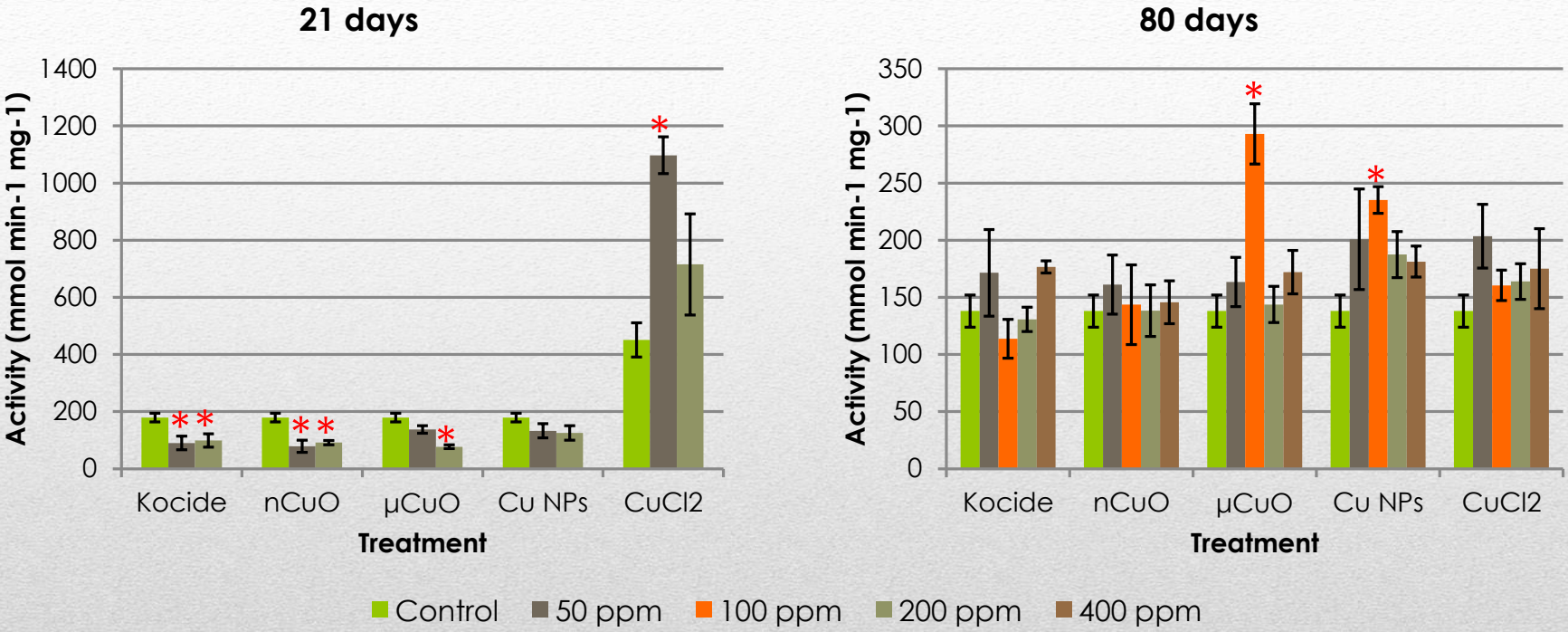
Chlorophyll Content



Catalase Activity

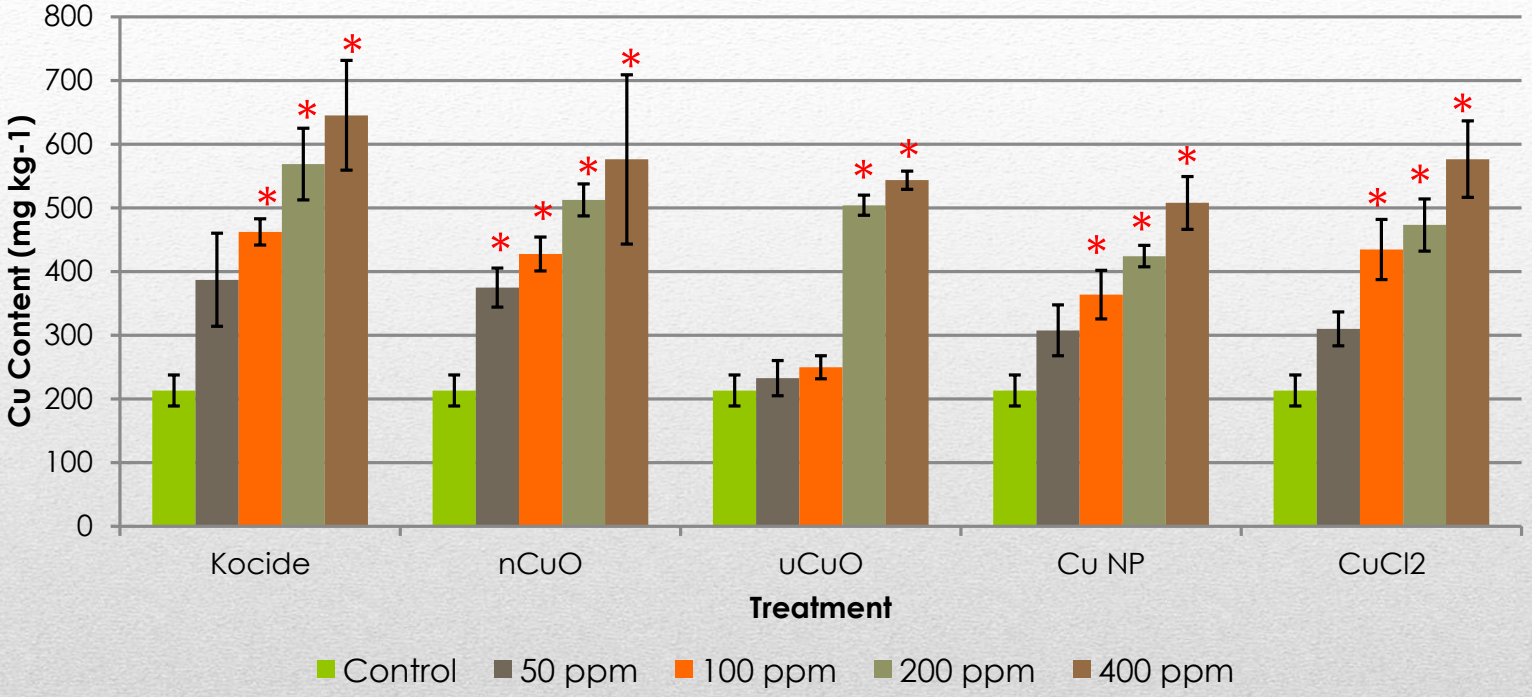


Ascorbate Peroxidase Activity



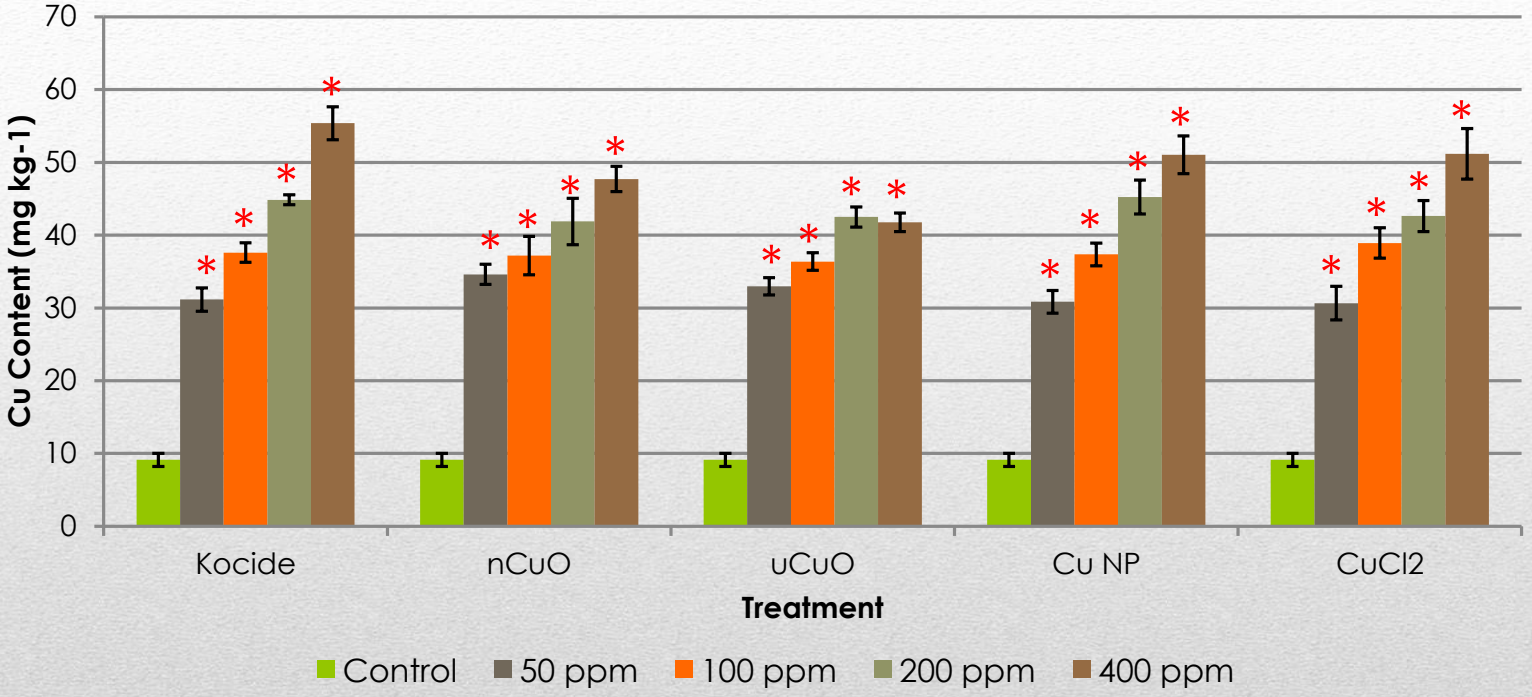
Ascorbate Peroxidase

21 days vs. 80 days



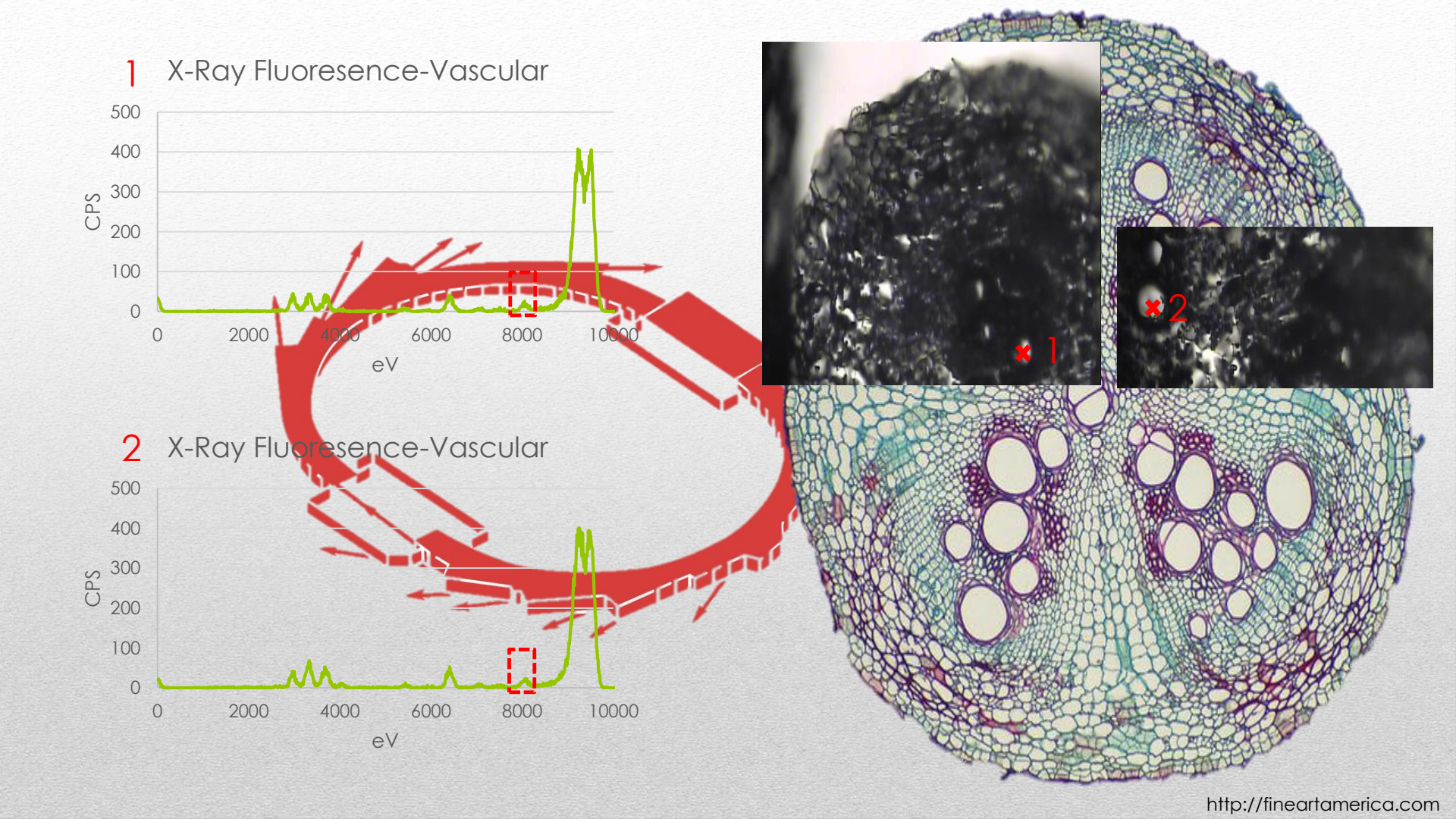
Copper Uptake

Roots



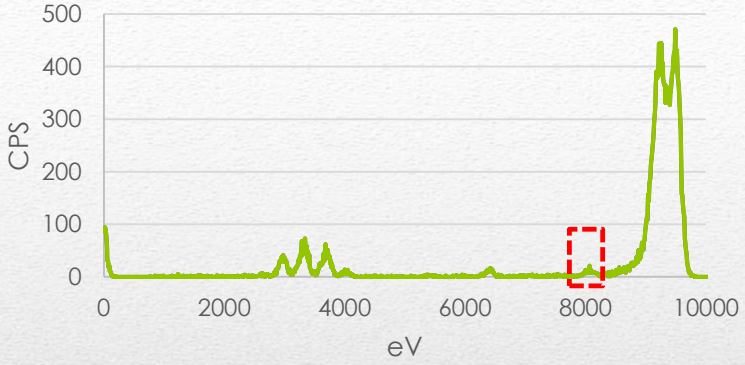
Copper Uptake

Flowers

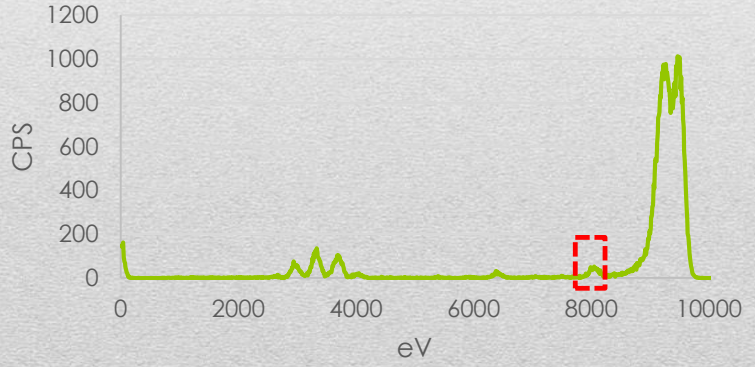


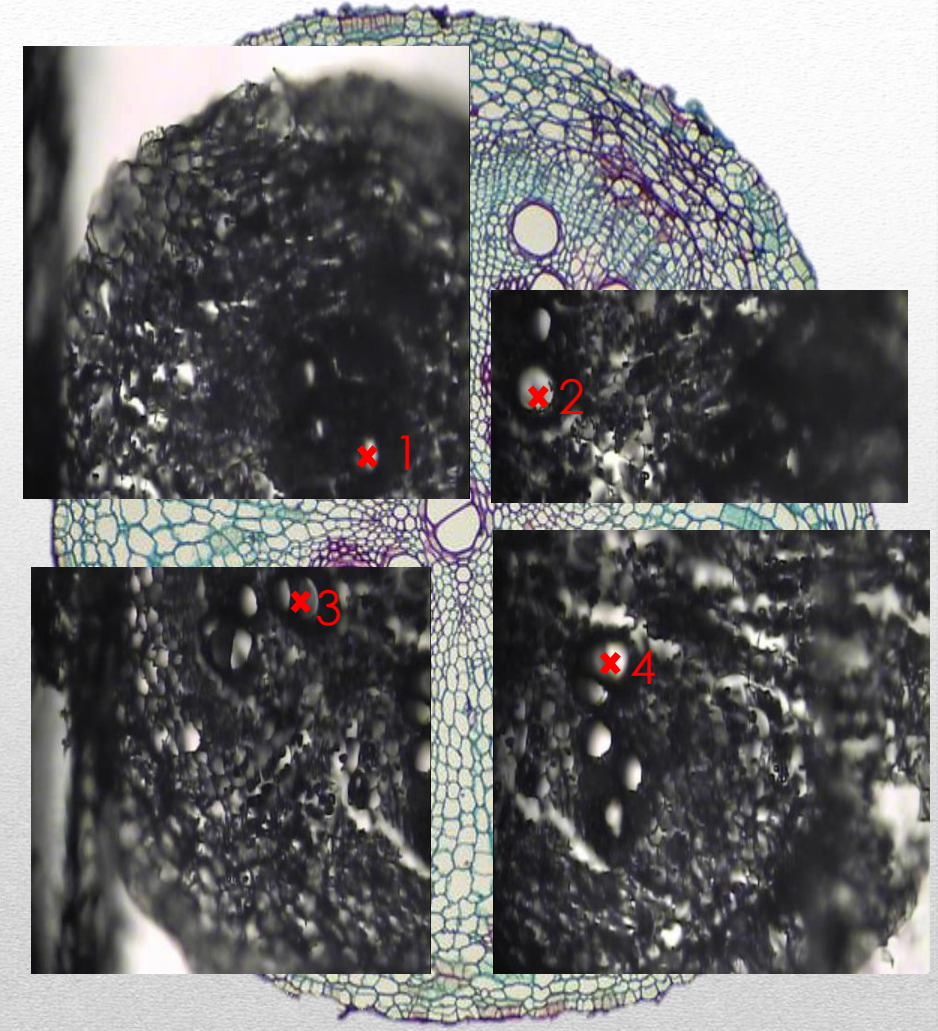
http://fineartamerica.com

3 X-Ray Fluoresence-Vascular



4 X-Ray Fluoresence-Vascular





http://fineartamerica.com

Conclusions

- No significant differences in plant height or root length.
- Only $CuCl_2$ showed a significant decrease in chlorophyll content.
- Catalase activity remained comparable to control levels, except for Cu NPs.

Conclusions

- Ascorbate peroxidase activity increase only in plants treated with μCuO at 100 ppm and with $CuCl_2$ at 100 ppm.
- Compared to a 3 week study, APX activity remained similar to control for nearly all treatments.

Conclusions

- Copper concentrations in the roots increased with all treatments.
- Copper was transfer to edible tissues, with flowers showing increases at every treatment level.

UNIVERSITY OF CALIFORNIA
UC CEIN Center for Environmental Implications of Nanotechnology

Acknowledgements