Metal oxide nanoparticles for management of Verticillium wilt of eggplant and Fusarium wilt of watermelon

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Micronutrients

Nutrition is the first line of defense against disease. Micronutrients protect roots against soilborne diseases by activating enzymes to create defense products.

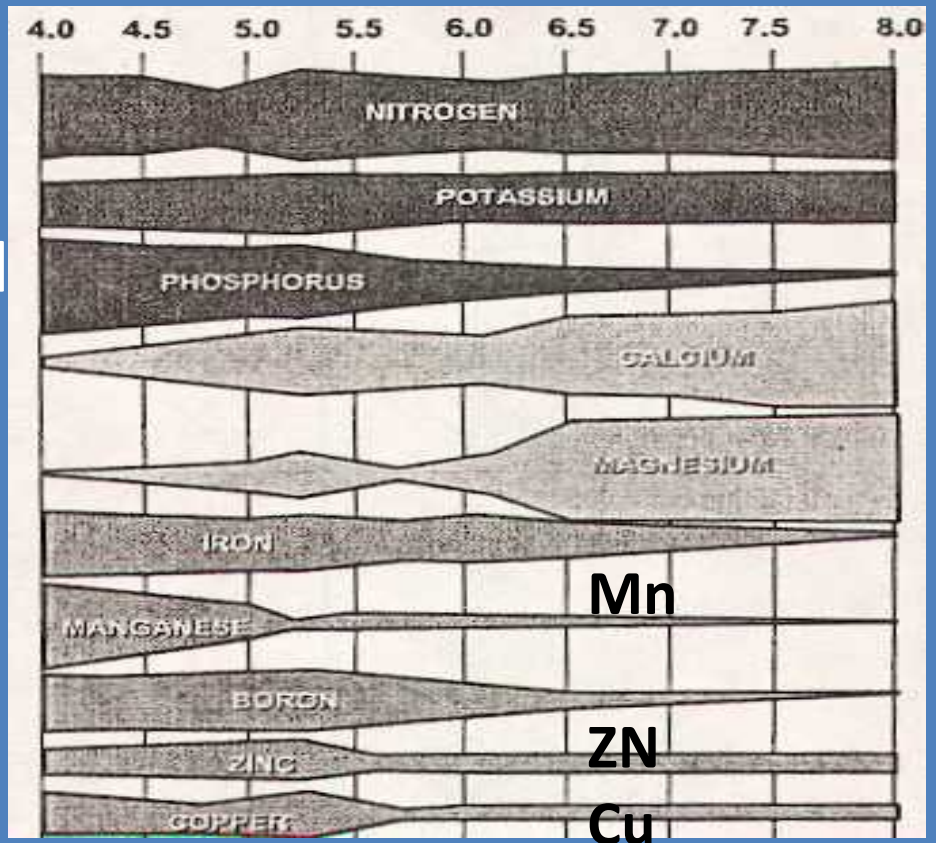
Cu	activates polyphenoloxidases
Mn	activates enzymes in the Shikimic acid and Phenylpropanoid pathways
Zn	activates superoxide dismutases

• The Obstacles

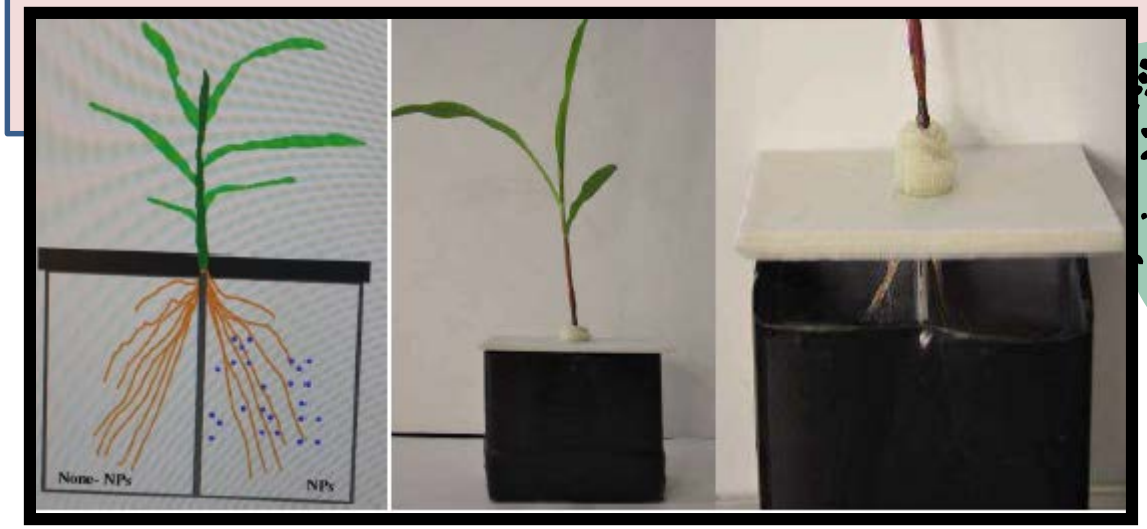
Increasing micronutrient levels in roots is problematic in neutral soils.

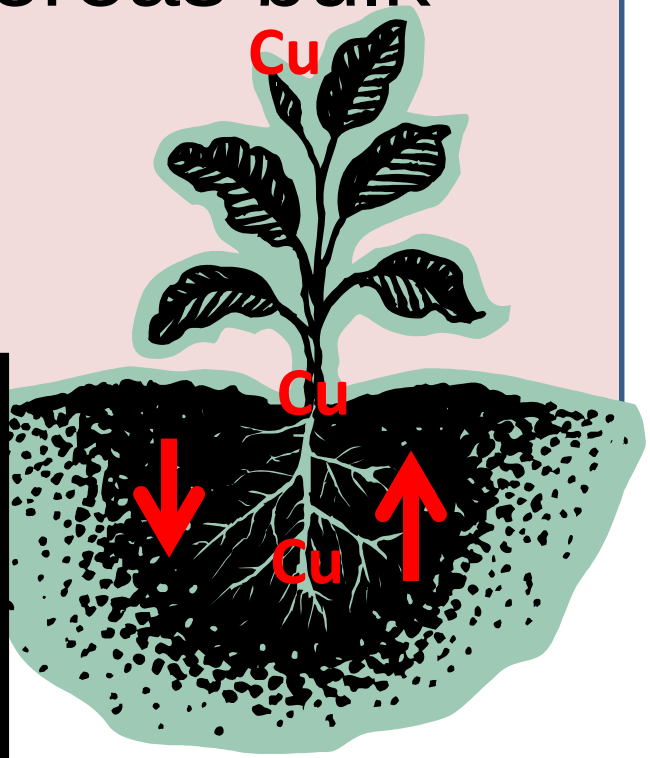
Micronutrients are not basipetally translocated

When applied to soil they frequently precipitate and become unavailable to the plant



Nanoparticles of CuO and other metals can move basipetally whereas bulk equivalents do not.





Wang, et al., 2012. Xylem- and Phloem-Based Transport of CuO Nanoparticles in Maize (*Zea mays* L.) Environ. Sci. Tech., 46:4434-4441.

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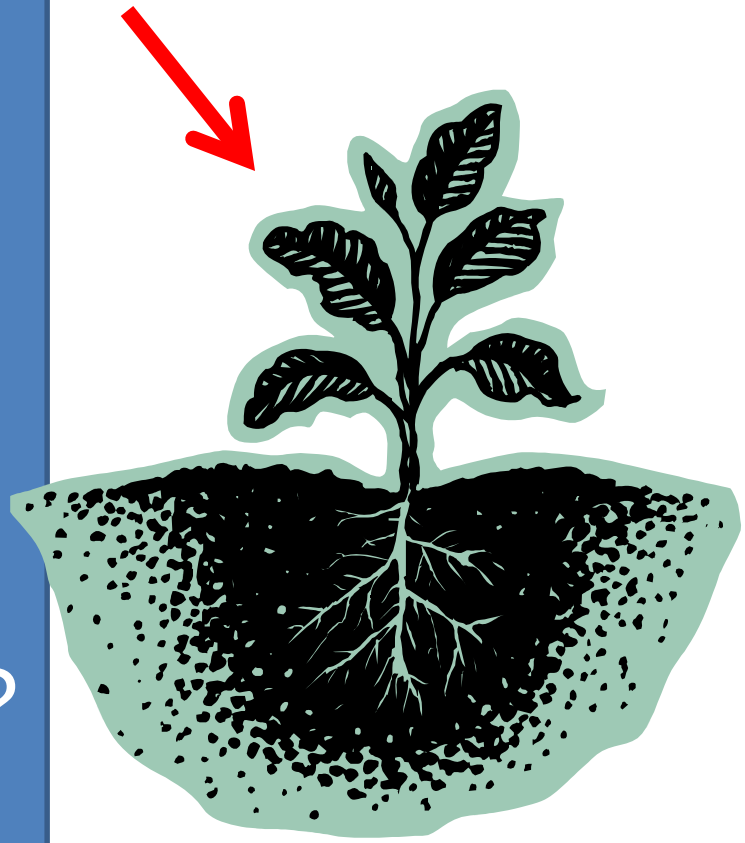
The Hypothesis

Would applying NP of micronutrients to leaves affect growth

Would these metals be translocated to roots?



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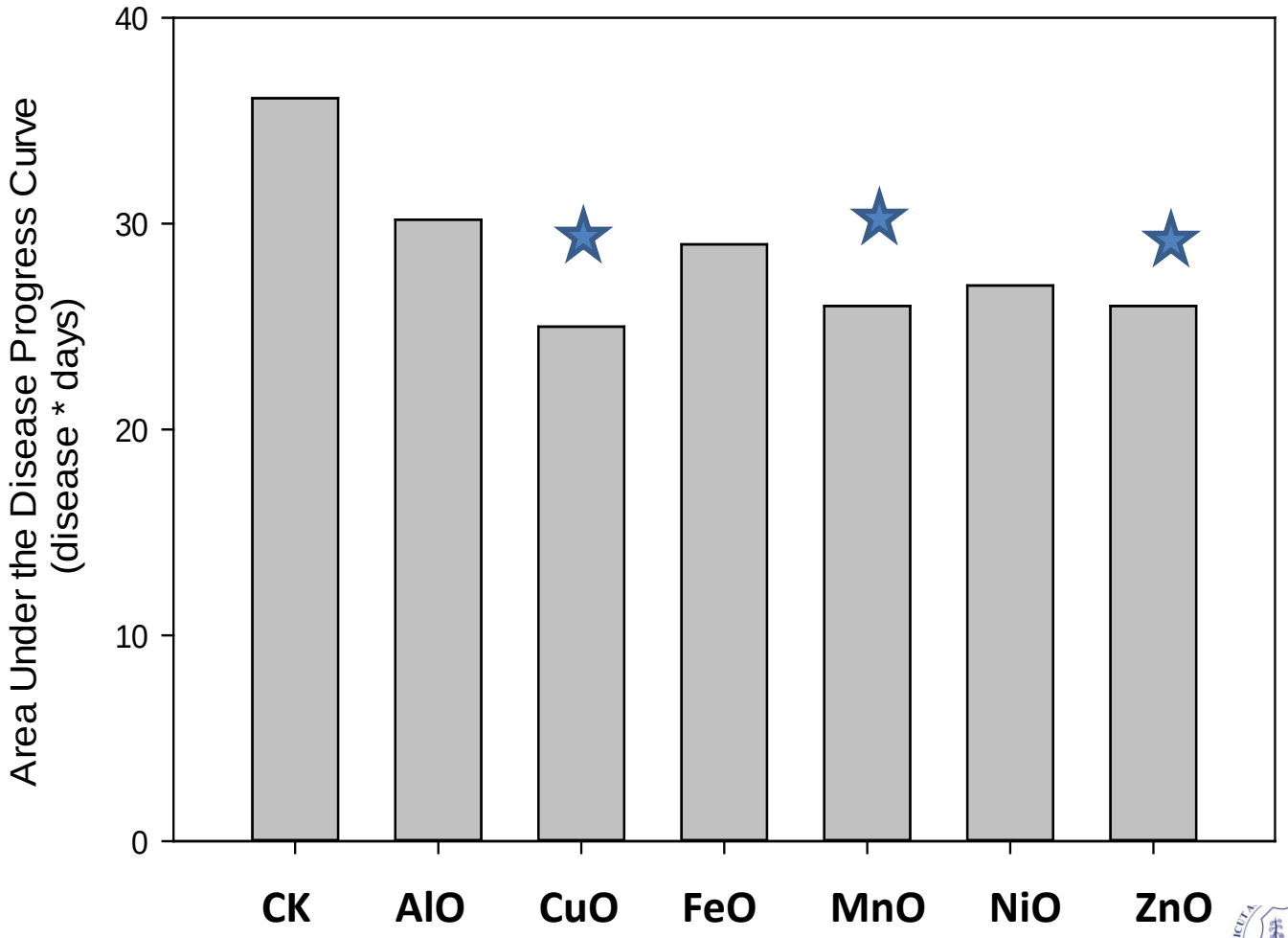
First studies were done on Fusarium wilt of tomato

- Two rates (100 ppm or 1,000 ppm) of nanoparticles of Al, Fe, Cu, Mn, Ni, or Zn were sprayed onto tomatoes in the greenhouse.

- Plants were inoculated with *Fusarium*.

Greenhouse tomato experiments



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Verticillium Wilt of Eggplant

Caused by soilborne fungus, *Verticillium dahliae*

Can reduced yields by 30%

Greenhouse experiments

- Would foliarly nanoparticles of Cu, Mn, or Zn suppress Verticillium wilt of eggplant?

- Would they behave the same as their bulked oxide equivalents?

Methods

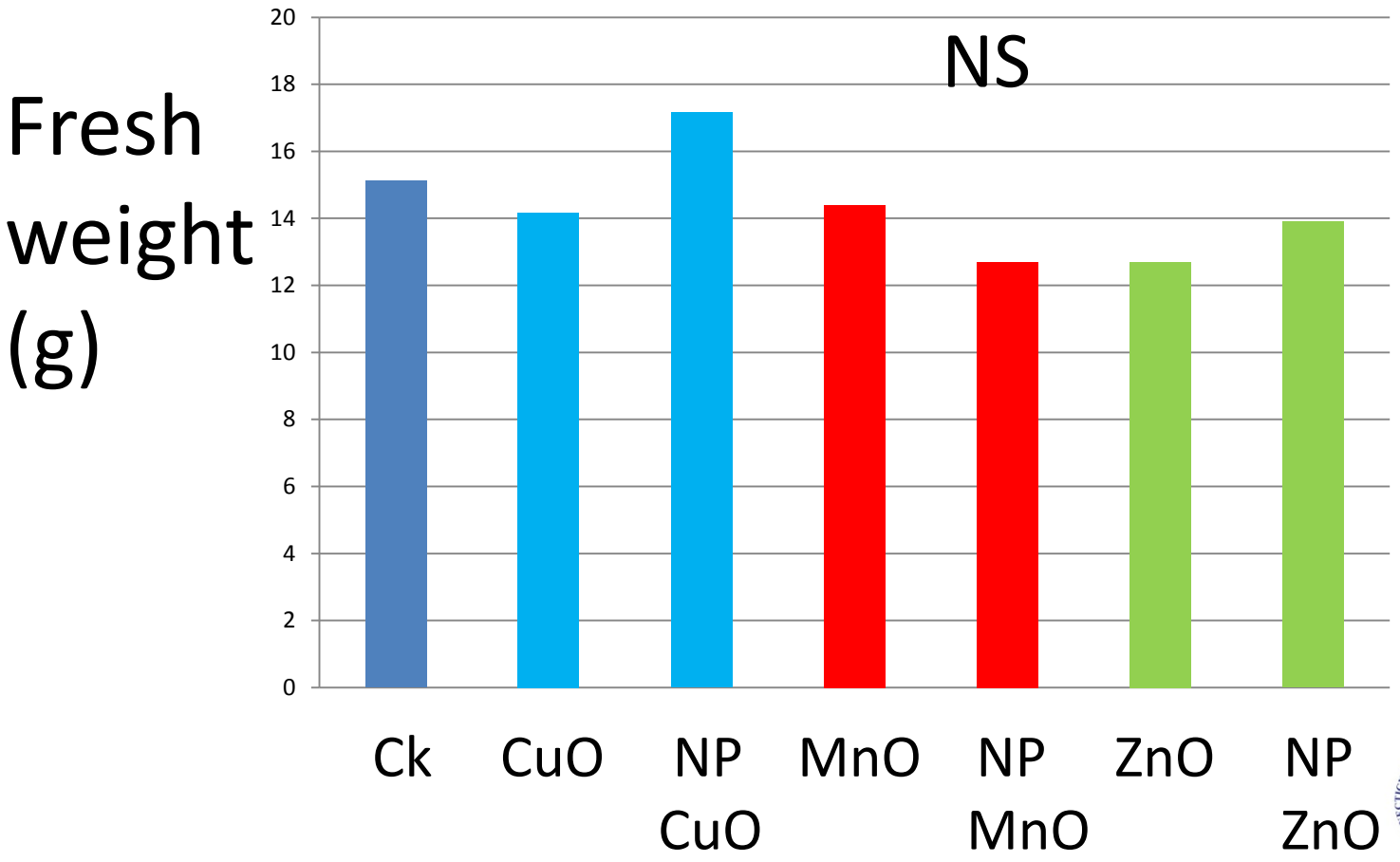
Nanoparticles of Cu, Mn, and Zn oxides were compared to the bulked oxide equivalent (1.0 mg/ml).

Bath sonicator

Plants were sprayed, allowed to dry and grown in soil with *V. dahliae.*

Growth and disease were measured.

Comparison of Nanoparticles to their bulked equivalent for effects on fresh weight of eggplants transplants in the greenhouse.



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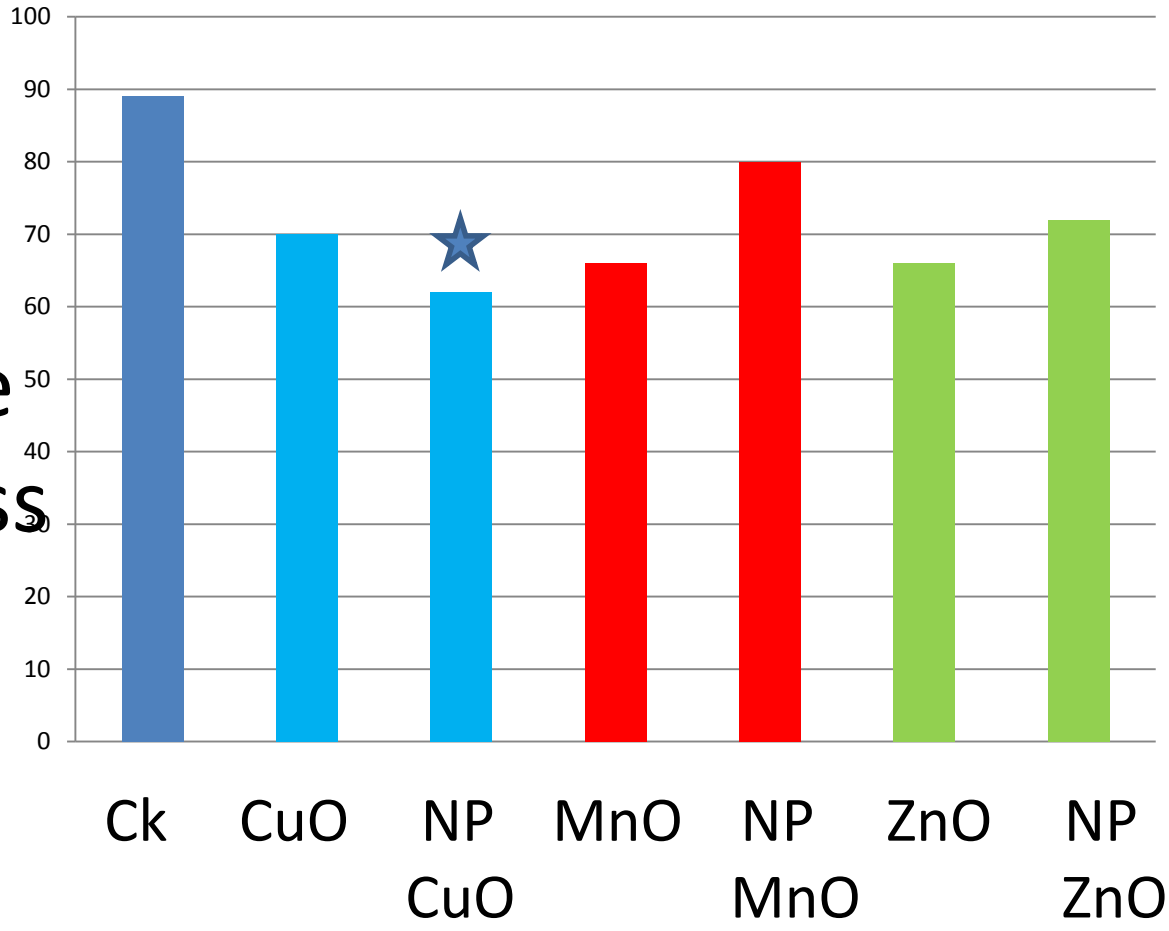
Comparison of NP to their bulked equivalent for disease progress on eggplant transplants in the greenhouse.

Area Under Disease Progress curve



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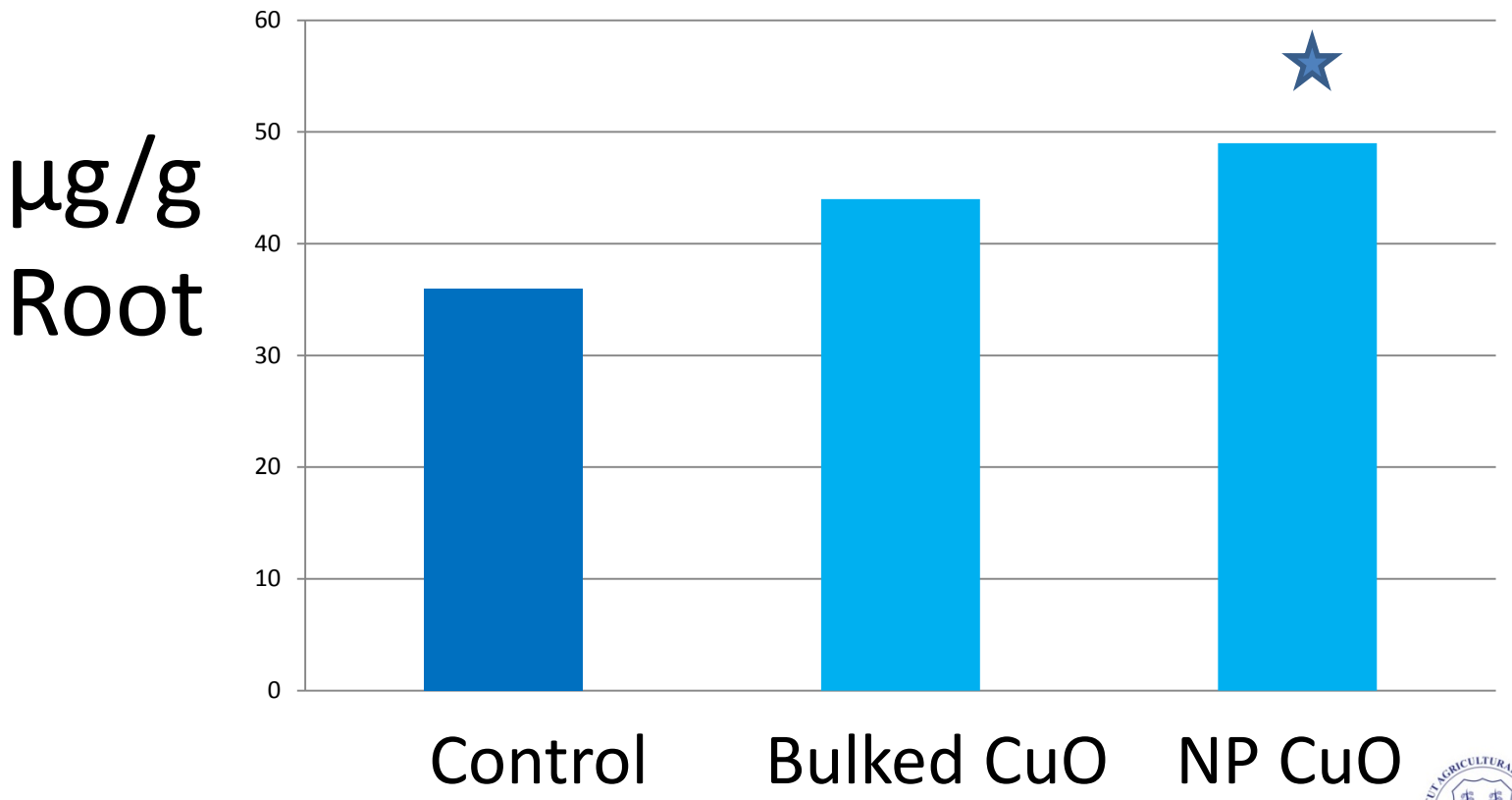
Cu levels in roots of eggplants treated with CuO NP or bulked oxide equivalents



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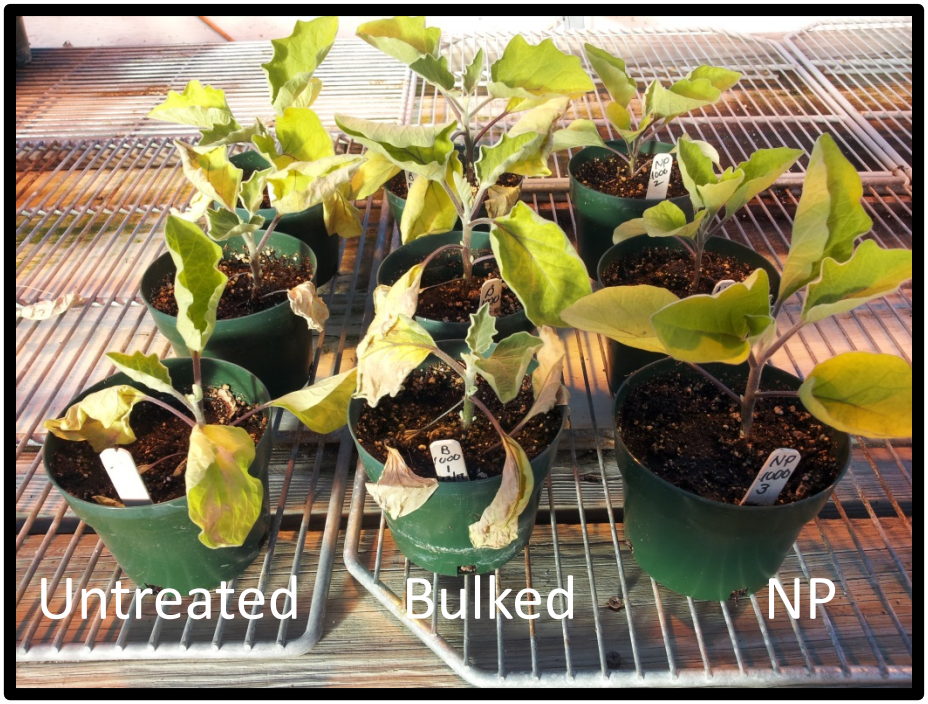
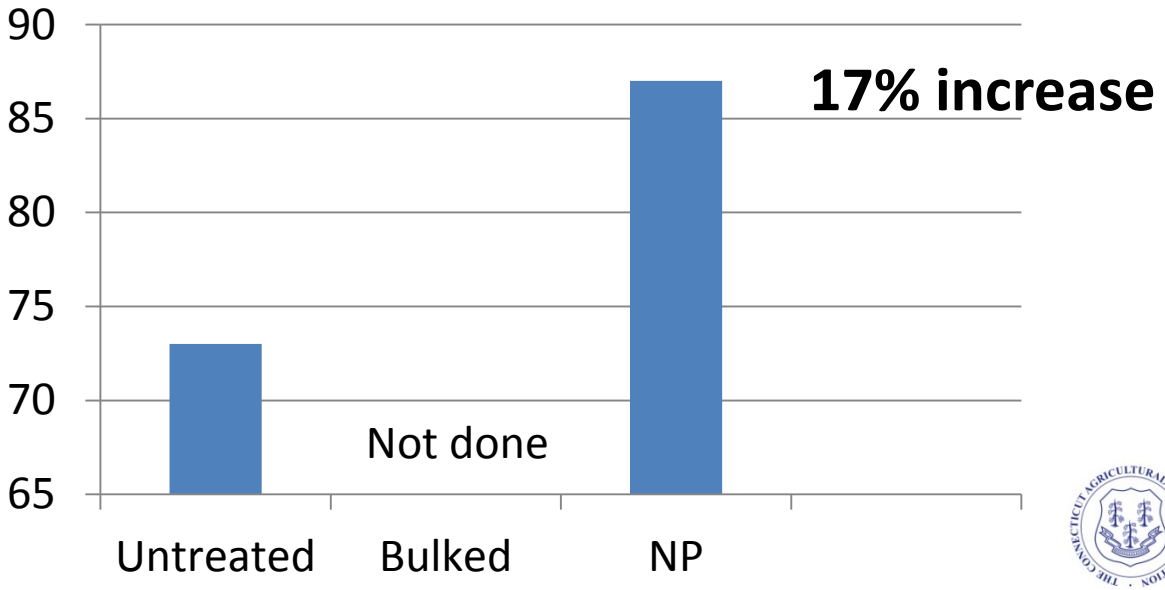


Root levels of Cu (µg/g)



17% increase

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Field Experiment

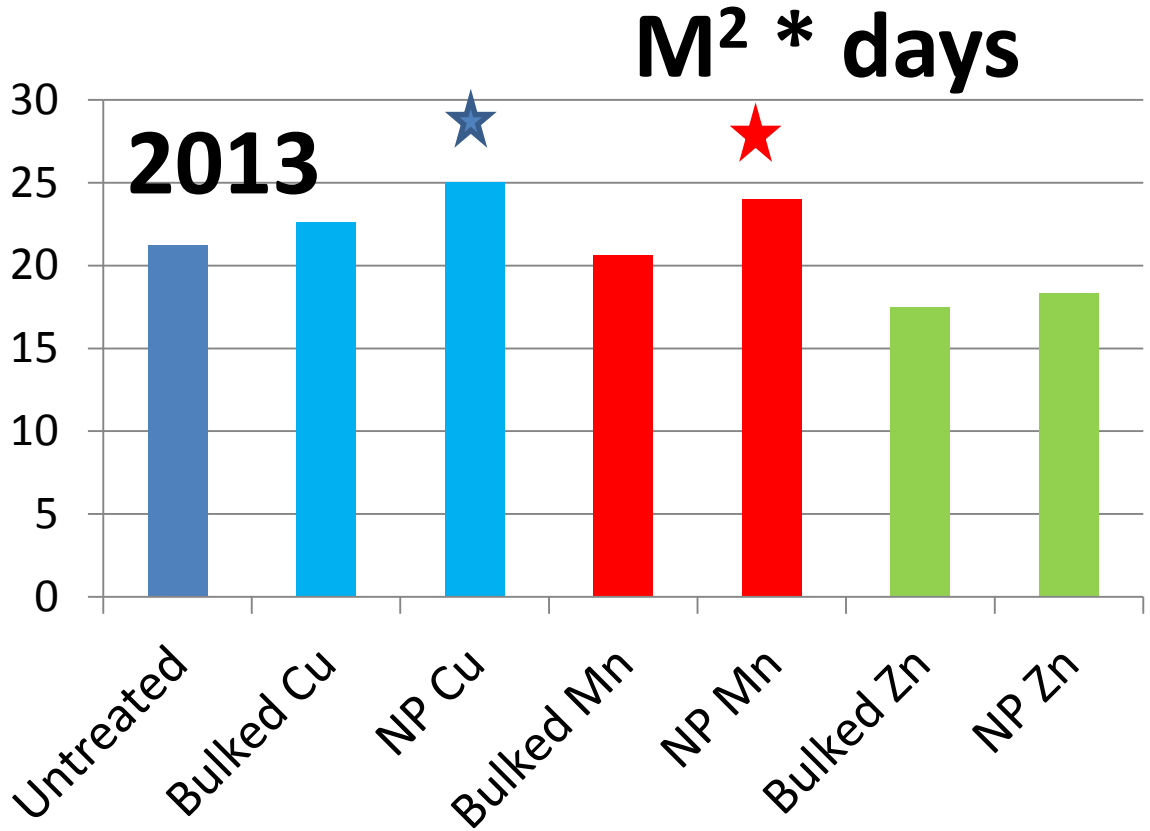
- Would nanoparticles of Cu, Mn and Zn suppress Verticillium wilt of eggplant?
- Would they affect yield?

Nanoparticle-Verticillium field trial on Eggplant 2013

Treatments

Control
CuO Bulk
CuO NP
MnO Bulk
MnO NP
ZnO Bulk
ZnO NP

Comparison of NP to the bulked equivalent on the canopy progress of eggplants with Verticillium wilt



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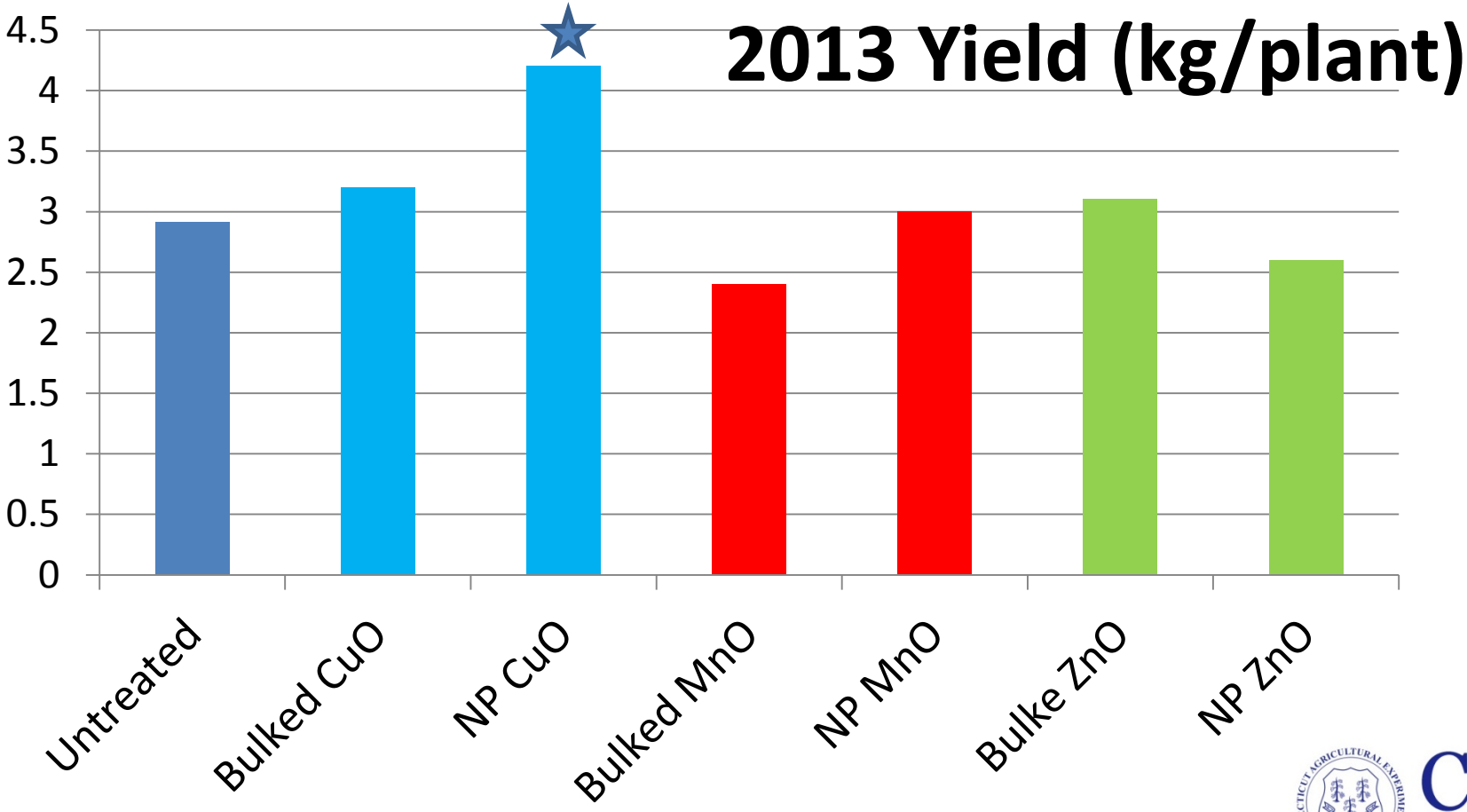
Comparison of Nanoparticles to their bulked equivalent for yield on eggplants with Verticillium wilt.



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Nanoparticle-Verticillium field trial on Eggplant 2014

Treatments

Control
CuO Bulk
CuO NP
MnO Bulk
MnO NP
ZnO Bulk
ZnO NP

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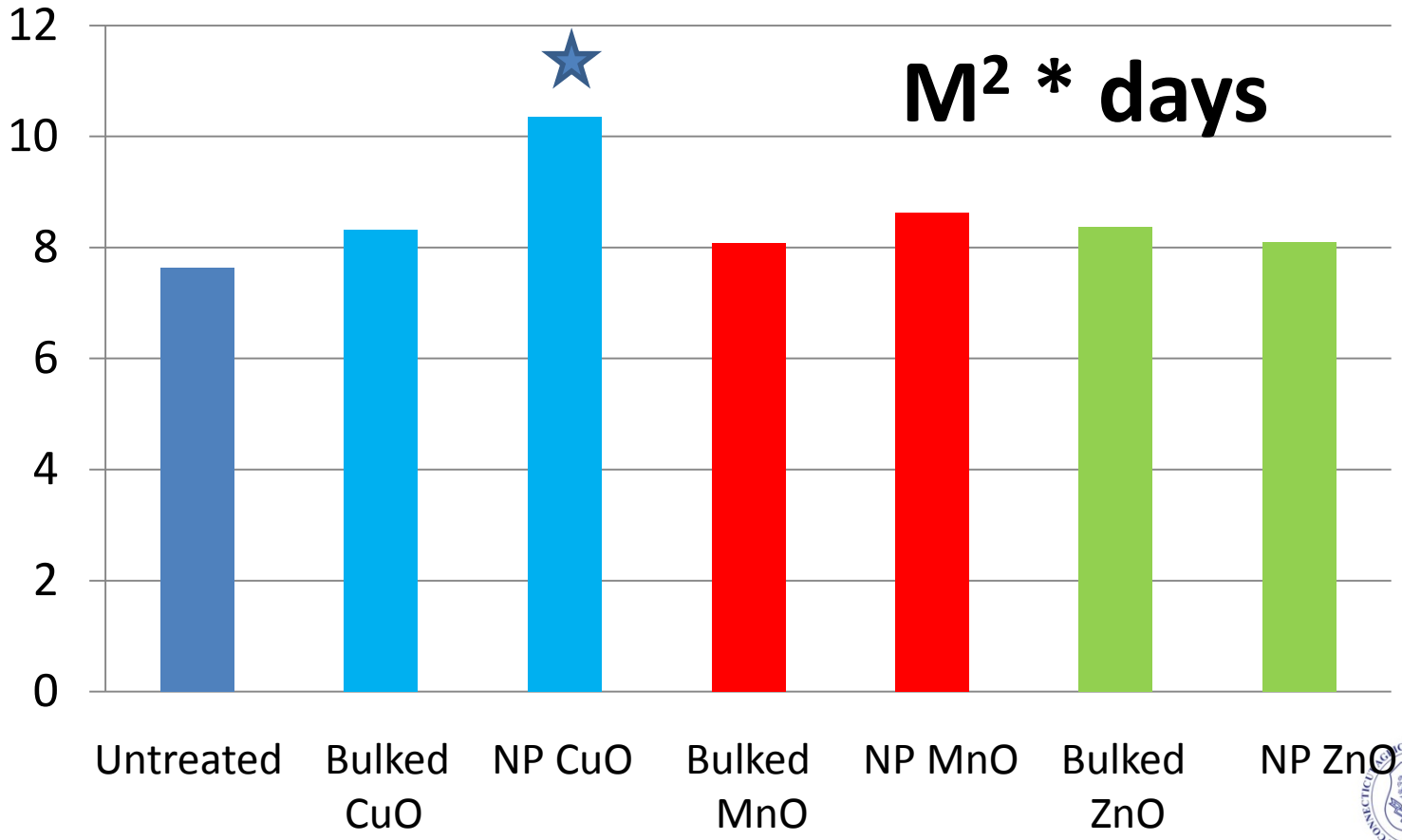
Comparison of NP to the bulked equivalent on the canopy progress of eggplants with Verticillium wilt 2014



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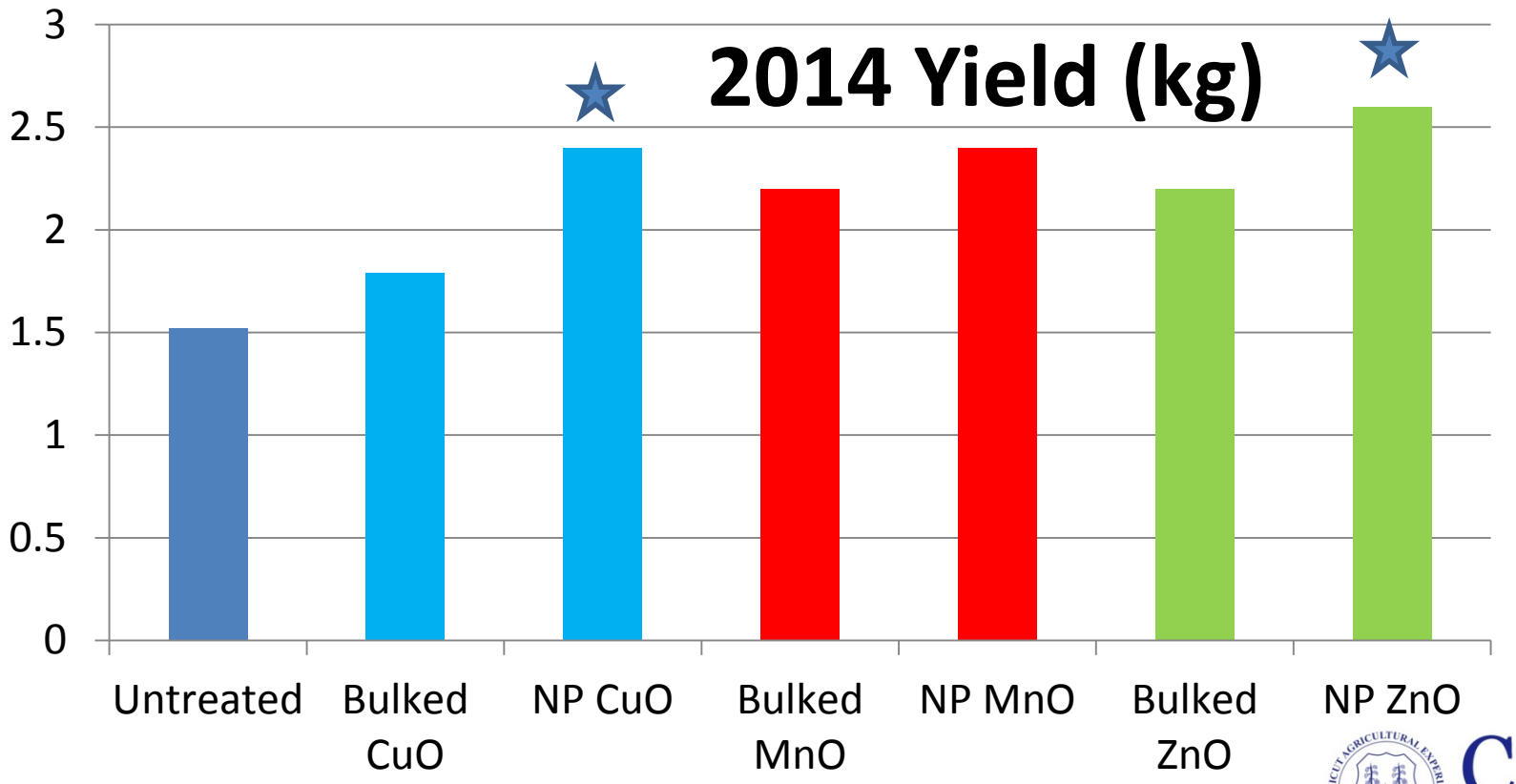
Comparison of Nanoparticles to their bulked equivalent for yield on eggplants with Verticillium wilt.



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Conclusions for Field Experiments (2013 & 2014)

- Nanoparticles of CuO increase yield in both years more than the untreated control and the bulked CuO.

- Fruit skin or flesh did not have elevated levels Cu when compared to controls.

Assume 2,500-3,000 eggplant transplants/A. So, 2,500 seedlings treated with 23 g CuO NP in 23 liters (1000 ppm) applied to run off) = costs $44.00.

We received a 17-31% increase over Bulked CuO (cost $18.40).

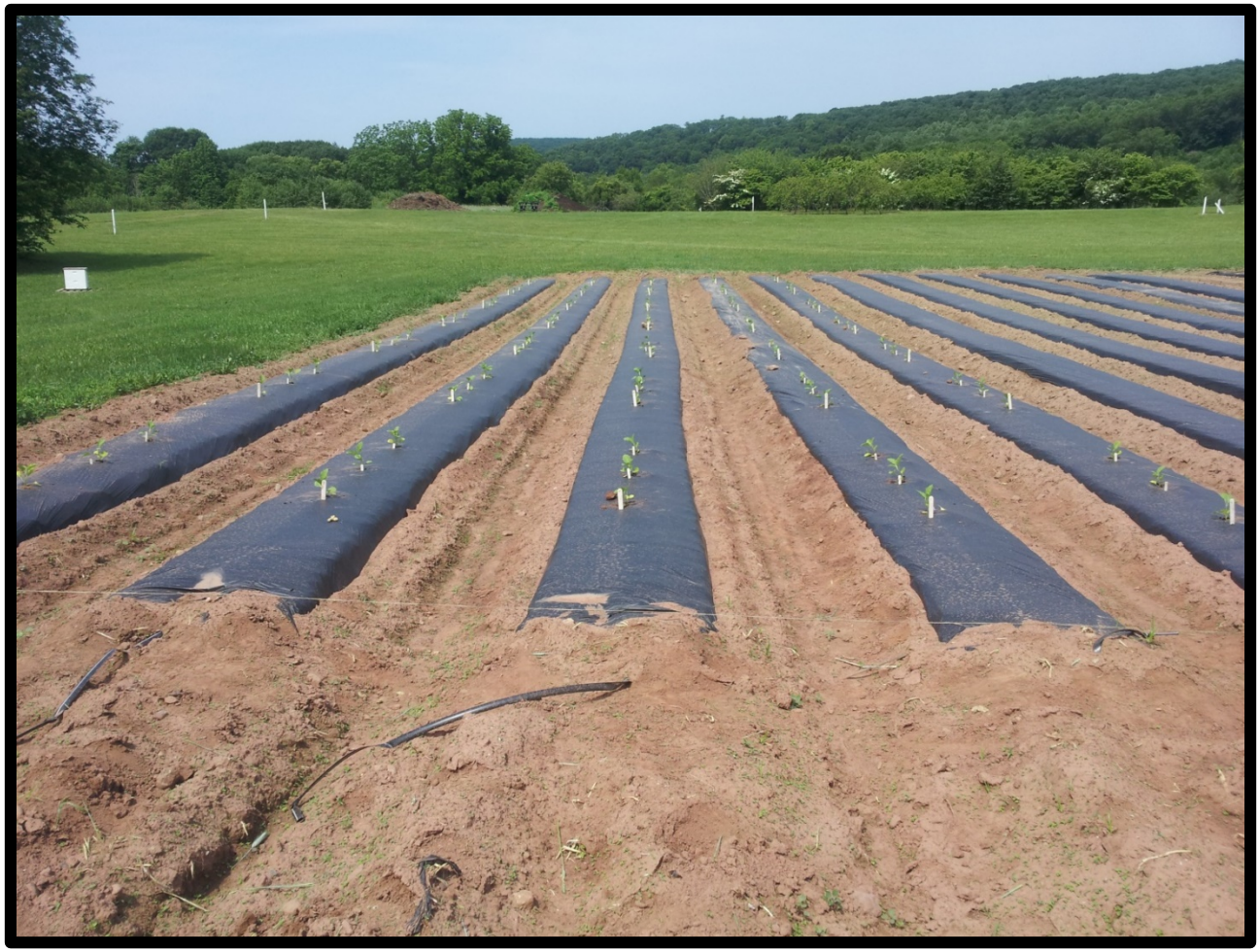
Eggplants averages = $17,500 - $20,000/A.

So a $44.00 investment could increase profits $5,526 - $6,315.

Nanoparticle-Verticillium field trial on Eggplant 2015

Treatments

Control
NP CuO 100
NP CuO 250
NP CuO 500
NP CuO 1000
Bulked 1000



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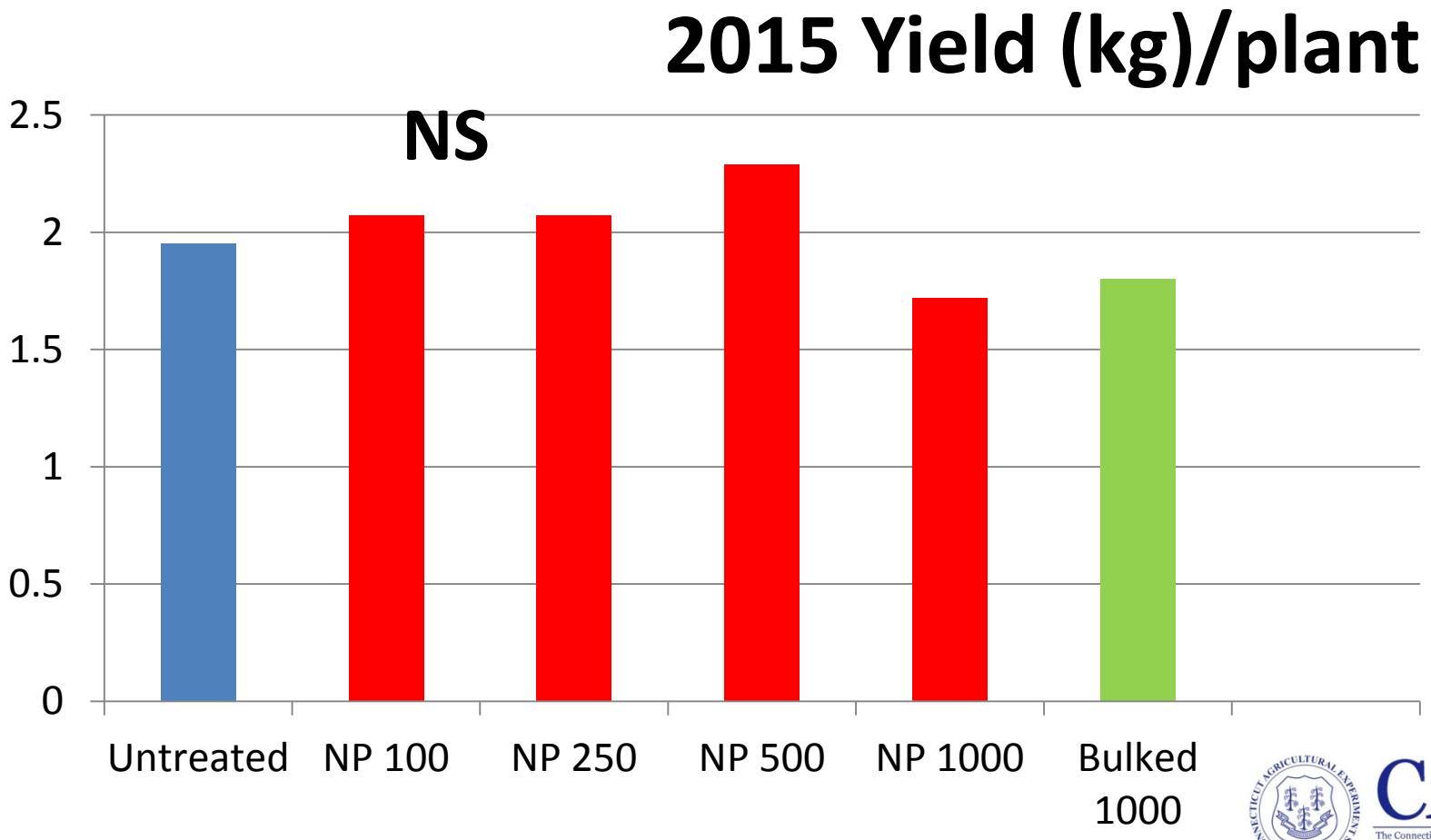
Effect of increasing rate of Nanoparticles of CuO on yield of eggplant affected by Verticillium wilt.



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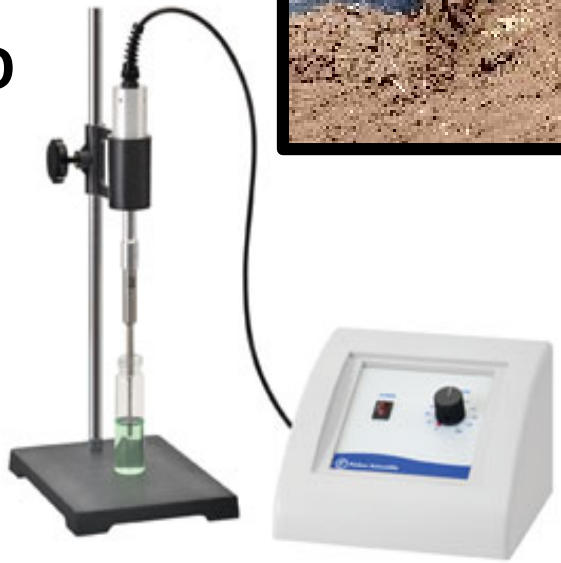
Nanoparticle-Verticillium field trial on Eggplant 2016

Treatments

Control
CuO
MnO
ZnO
CuO + MnO
CuO + ZnO
MnO + ZnO
CuO + MnO + ZnO



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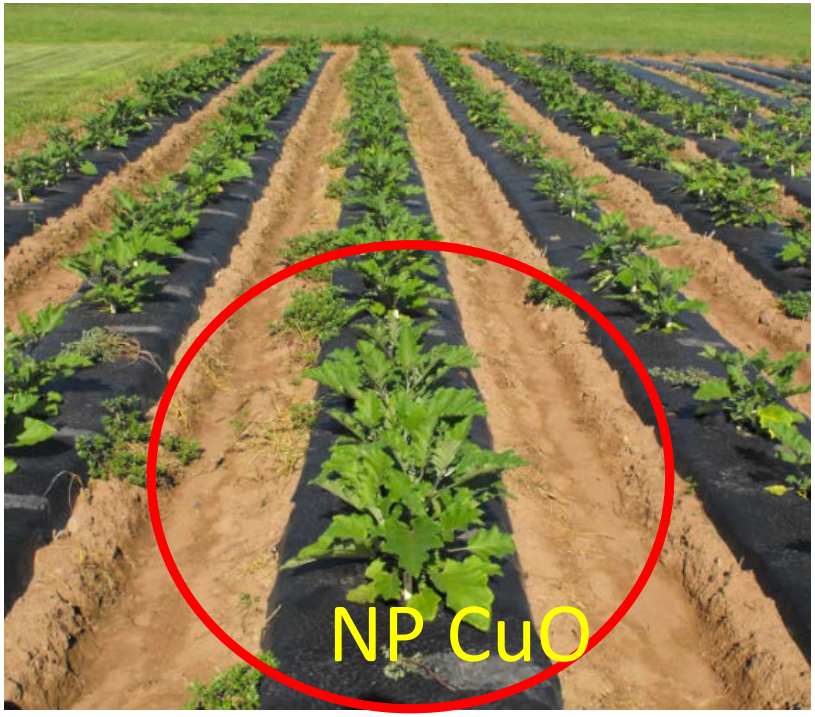
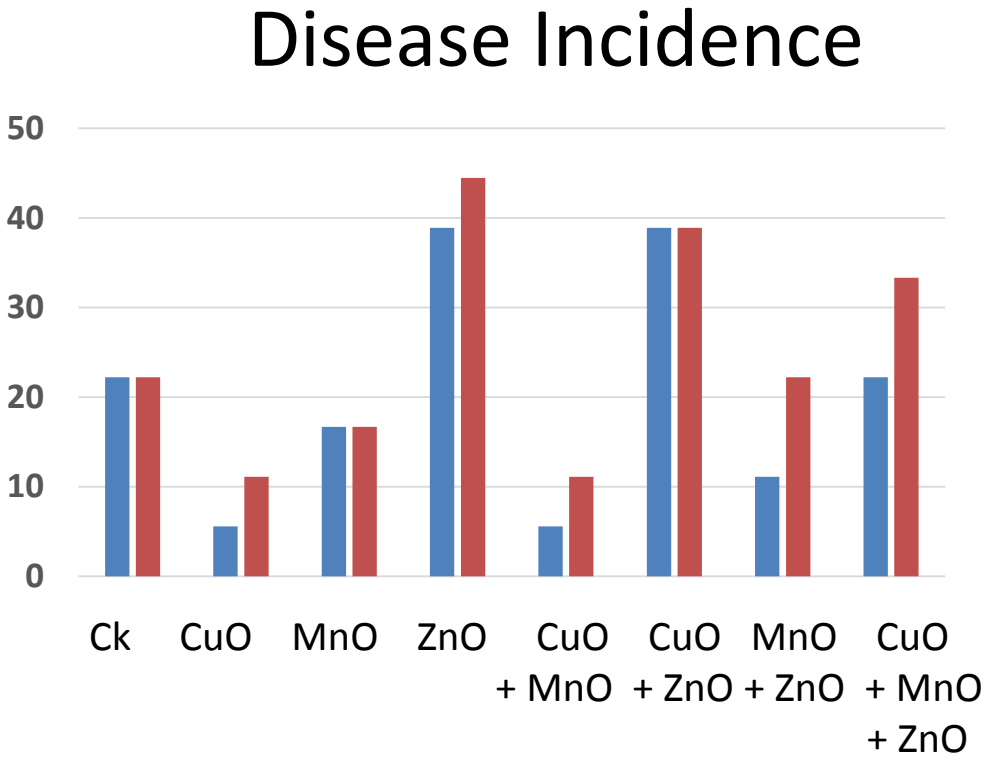
Nanoparticle-Verticillium field trial on Eggplant 2016





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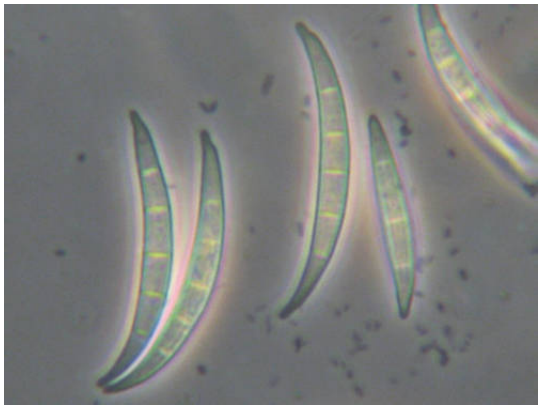
Fusarium Wilt of Watermelon

Caused by *Fusarium oxysporum* f. sp. *niveum*



2013 Florida Growables

Watermelon Experiment 1

Would nanoparticles of Cu, Mn, Si, Ti, or Zn increase or decrease Fusarium disease on watermelon.

Compared NP vs Bulked oxides.

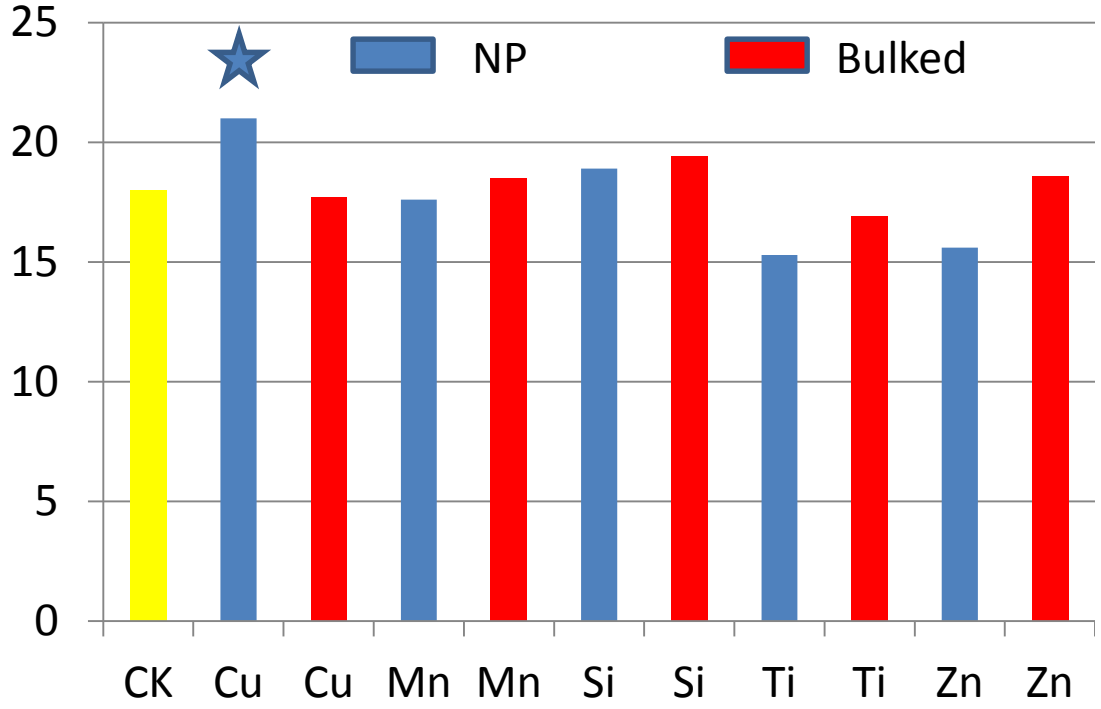
Methods

NP or bulked equivalents of of Cu, Mn, Si, Ti, or Zn oxides were sprayed onto watermelons in the greenhouse.

Plants were inoculated with conidial drench of *Fon*

Effect of Bulked vs NP of Cu, Mn, Si, Ti and Zn oxides on growth of watermelon infested with Fusarium wilt in the greenhouse.

Fresh Weights (g)



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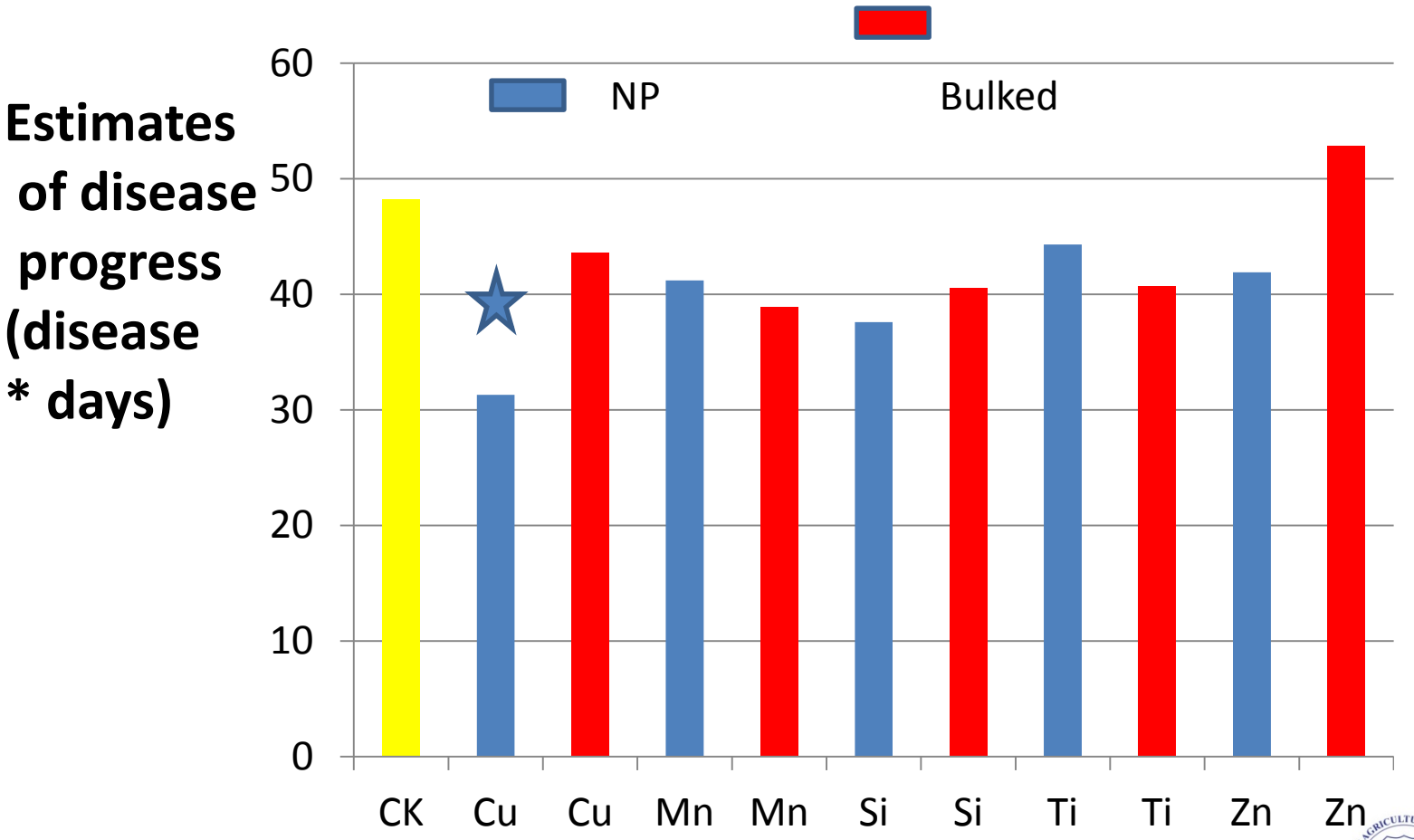
Effect of Bulked vs NP of Cu, Mn, Si, Ti and Zn oxides on the disease progress of watermelon infested with Fusarium wilt in the greenhouse.



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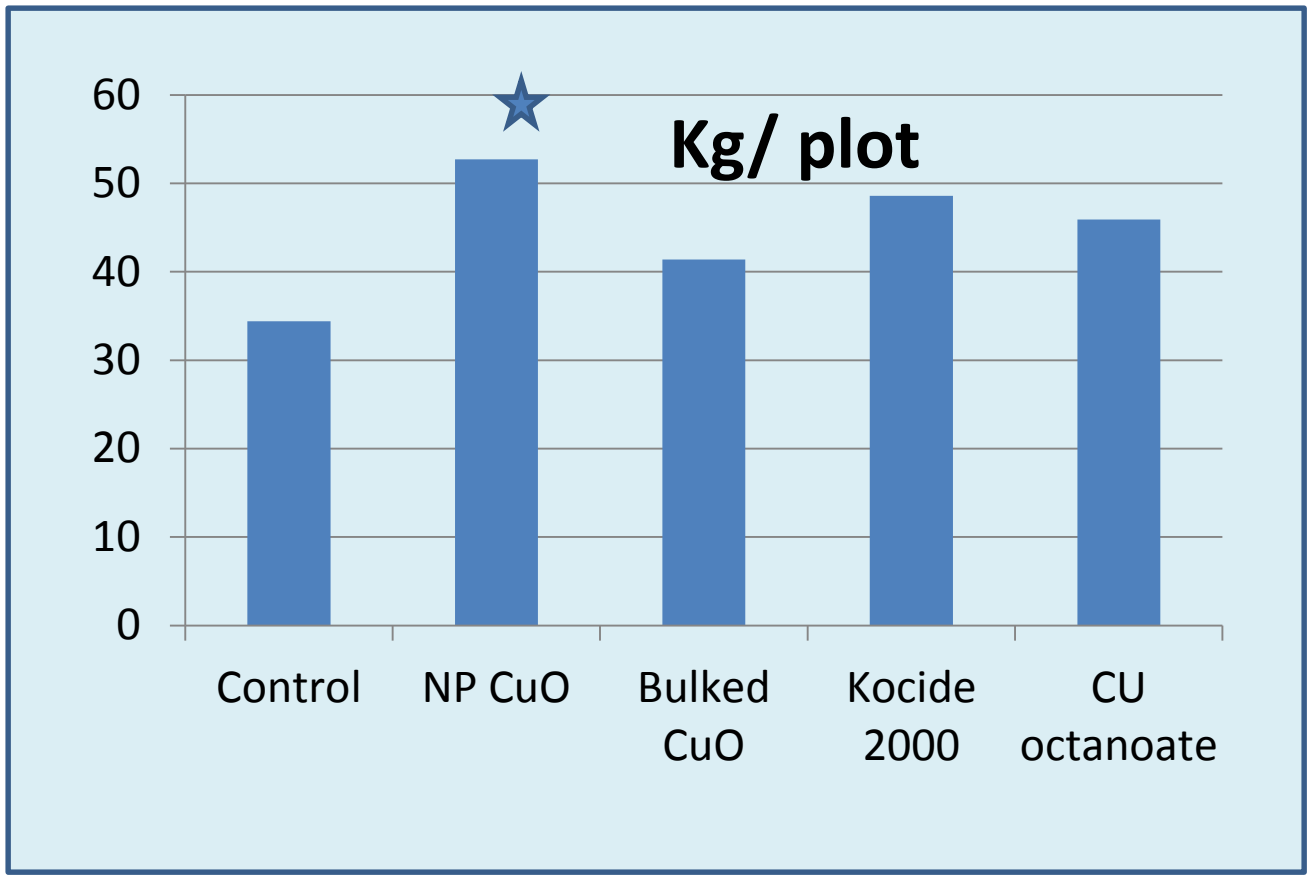
Effect of Cu applied as NP of CuO, Bulked CuO, Kocide 2000, or Cu octoantate on yield (kg/plant) of watermelons



Digests of edible flesh found no differences in Cu levels among Treatment

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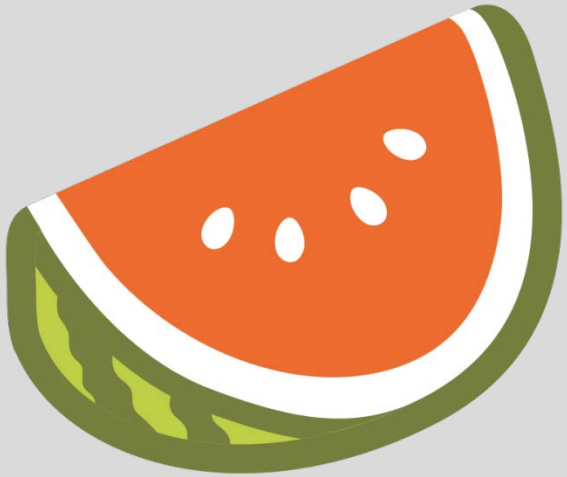
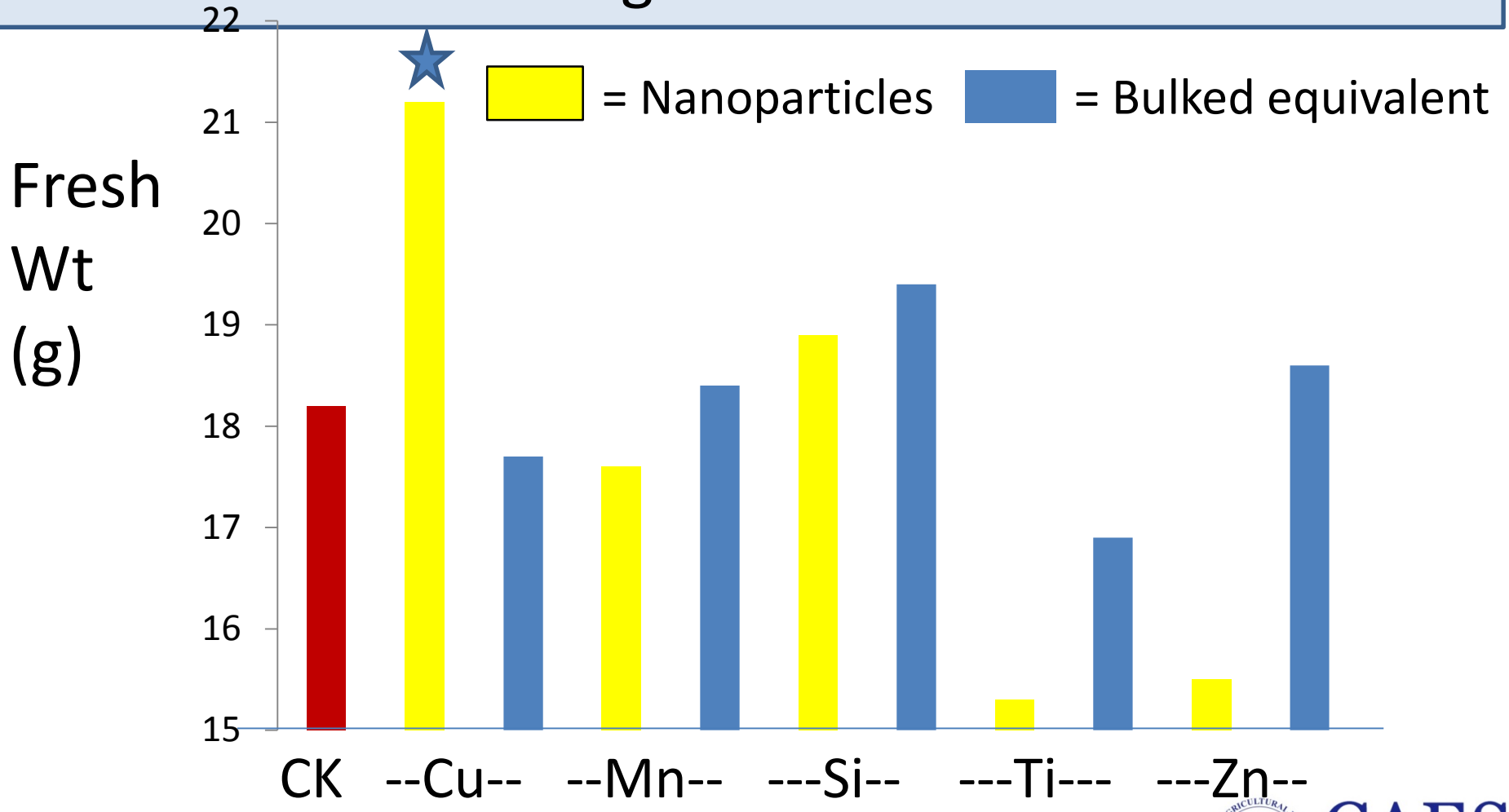
Methods



NP or bulked equivalent of
of Cu, Mn, Si, Ti, or Zn
oxides were sprayed onto
watermelons in the greenhouse.

Plants were inoculated
with conidial drench of *Fon*

Comparison of Nanoparticles of Cu, Mn, Si, Ti and and Zinc to their large bulked equivalent for effect on watermelon fresh weights.



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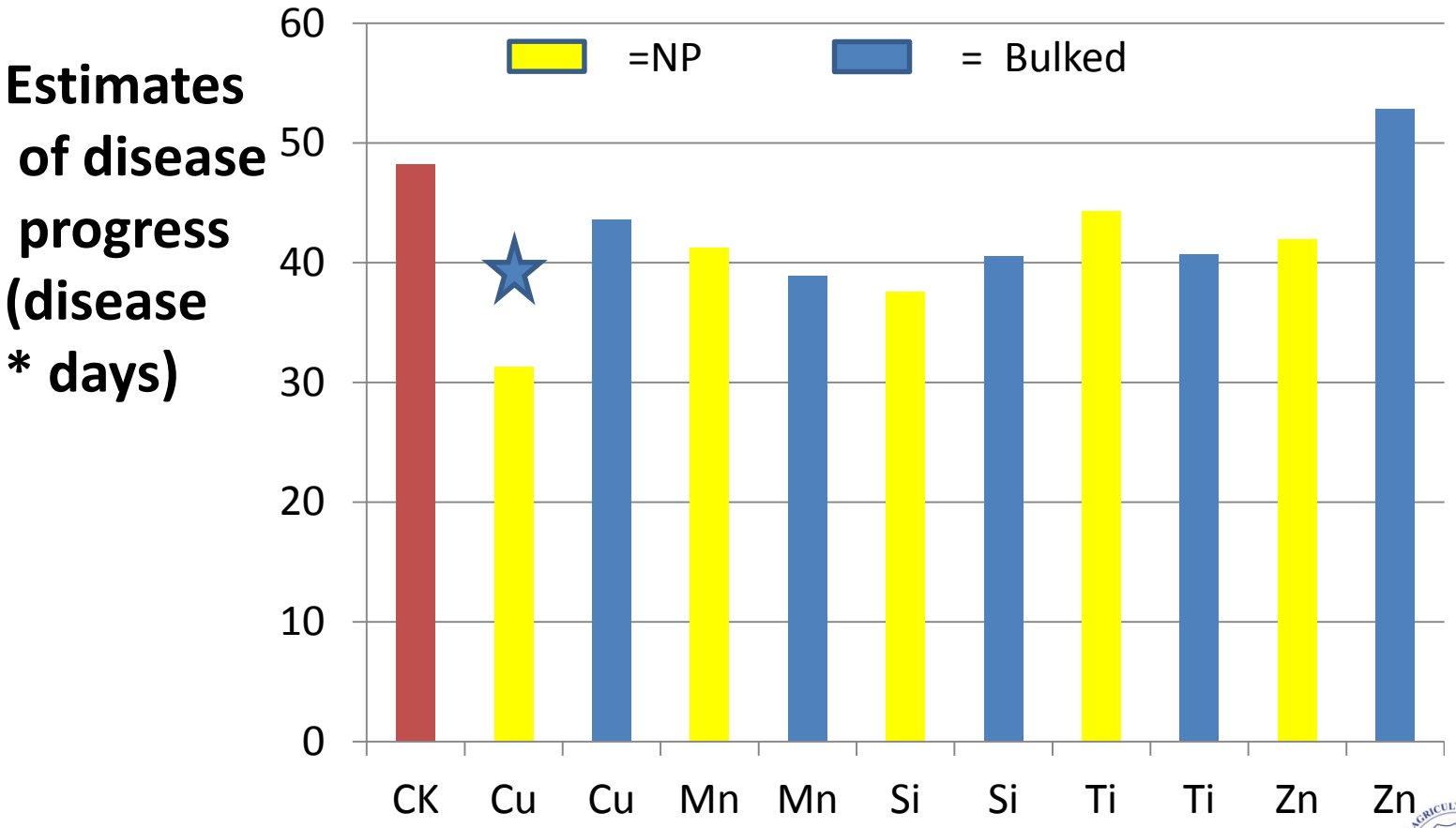
Comparison of Nanoparticles of Cu, Mn, Si, Ti and and Zn to their bulked equivalents for estimates of disease progress of Fusarium wilt of watermelon.



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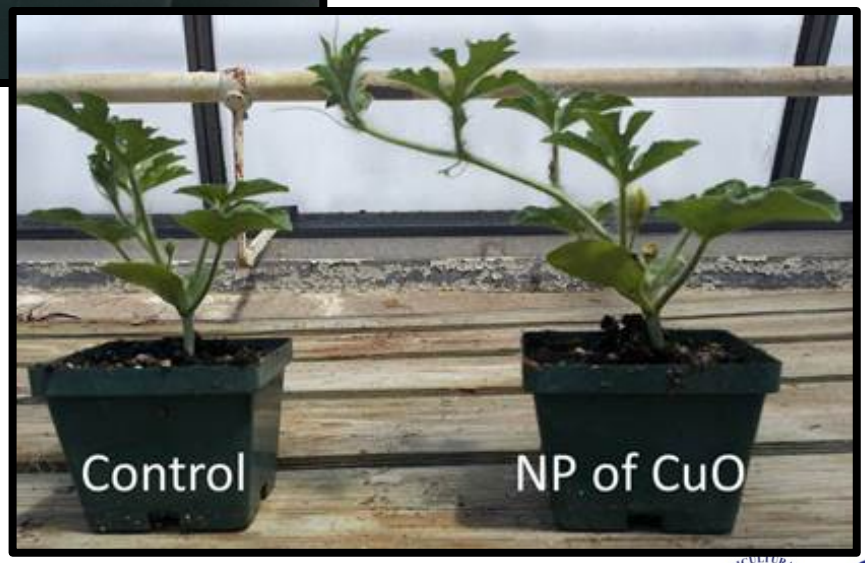
Foliar application of CuO NP (1000 PPM)

Control NP of CuO



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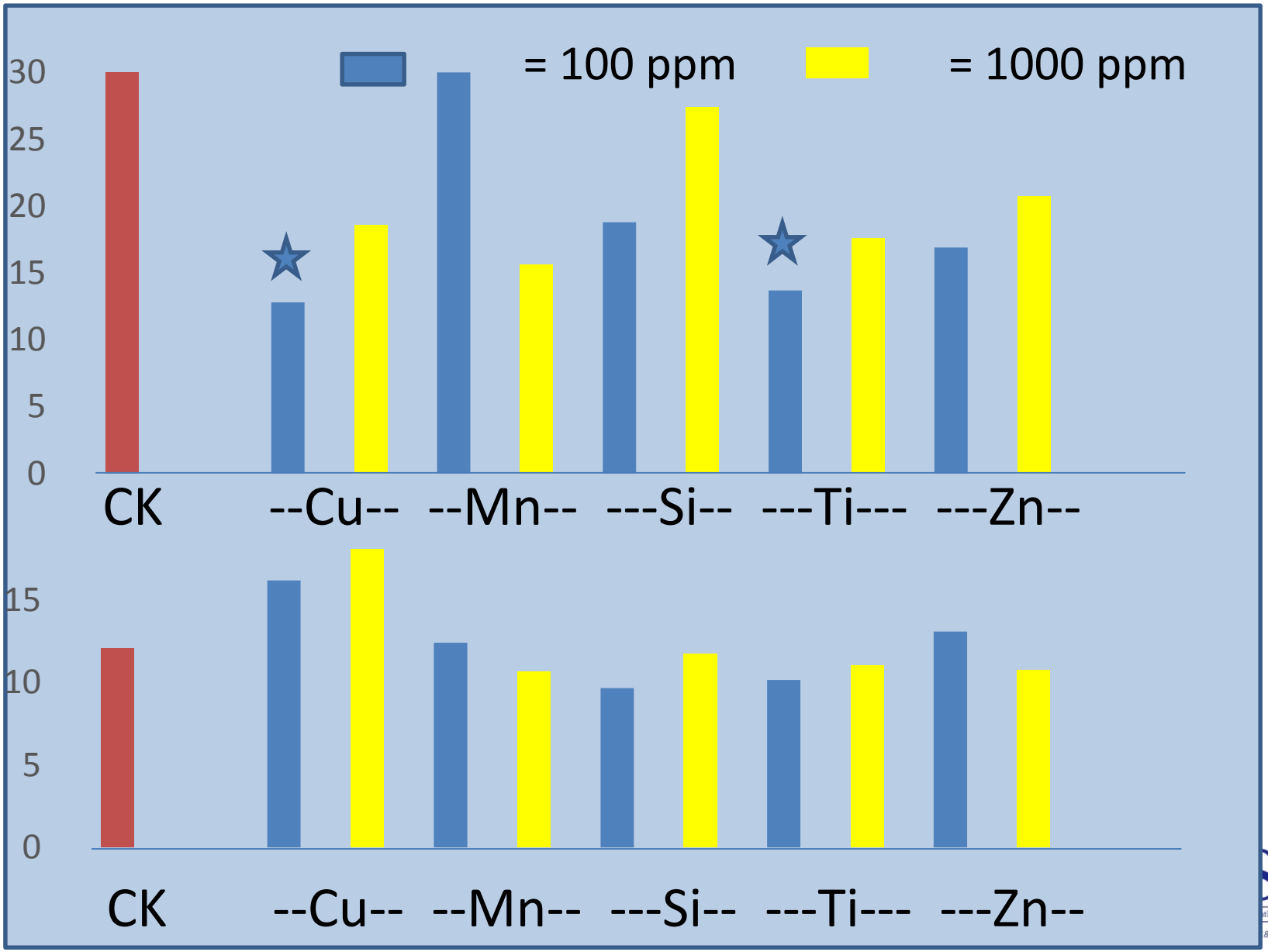
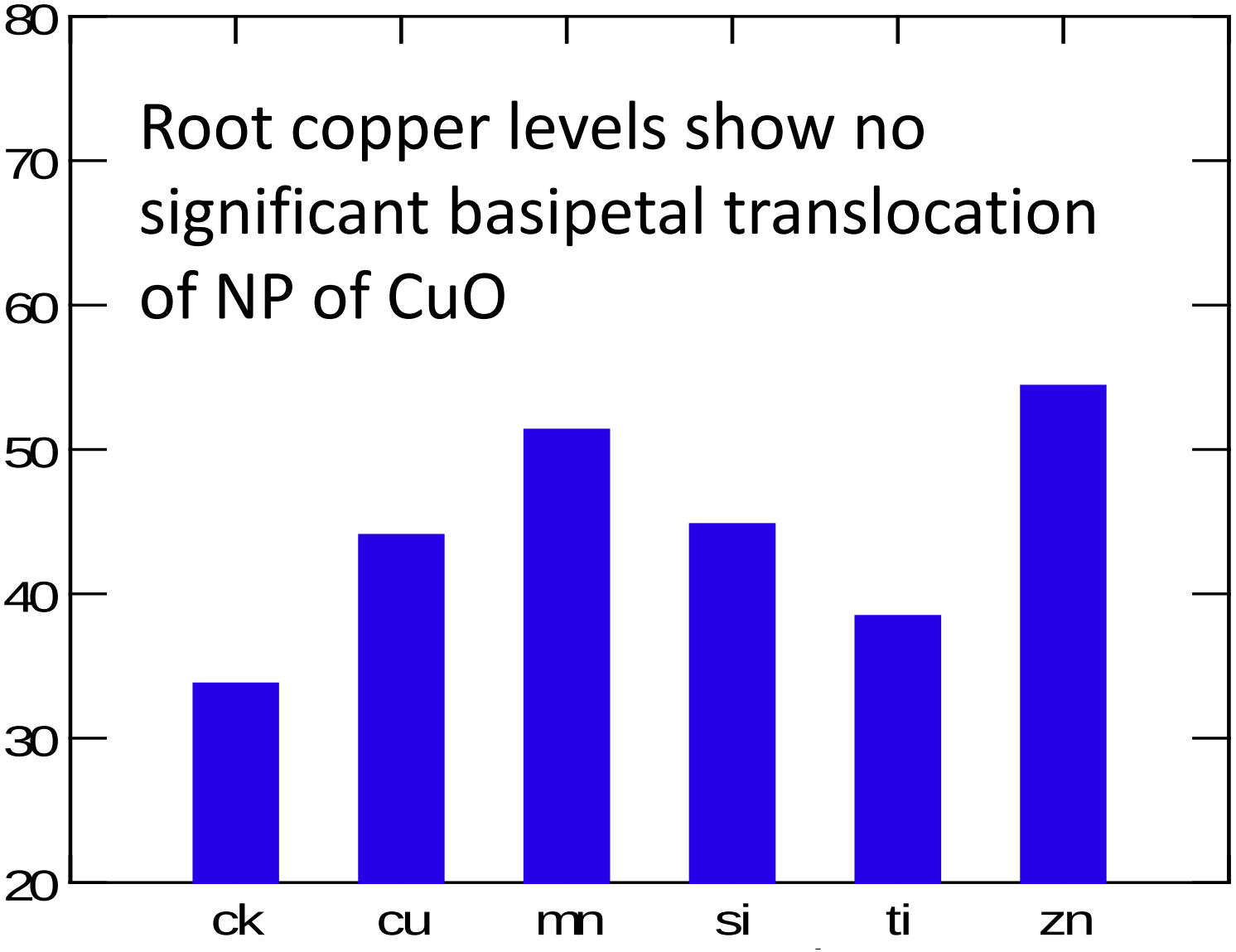
Comparison of Nanoparticles rate of Cu, Mn, Si, Ti and Zinc for on watermelon fresh weights inoculated with FON.





Field studies 2015

Treatments

1. Control
2. NP of CuO
3. Bulked CuO
4. Kocide 2000
5. Organic Cu soap
   (Cu octanoate)

Applied twice to seedlings in greenhouse

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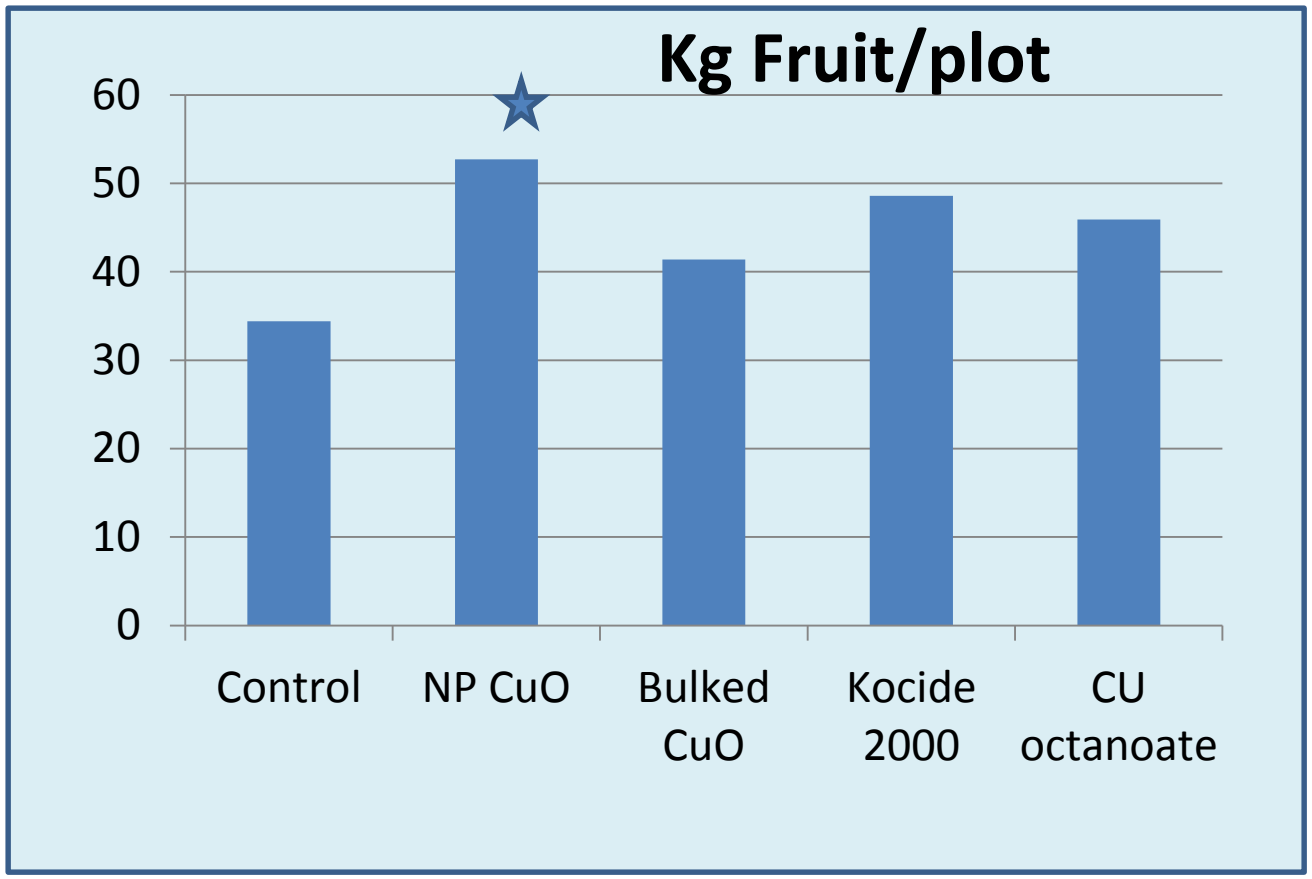
Effect of Cu applied as NP of CuO, Bulked CuO, Kocide 2000, or Cu octoantate on yield (kg/plant) of watermelons



Digests of edible flesh found no differences in Cu levels among Treatment

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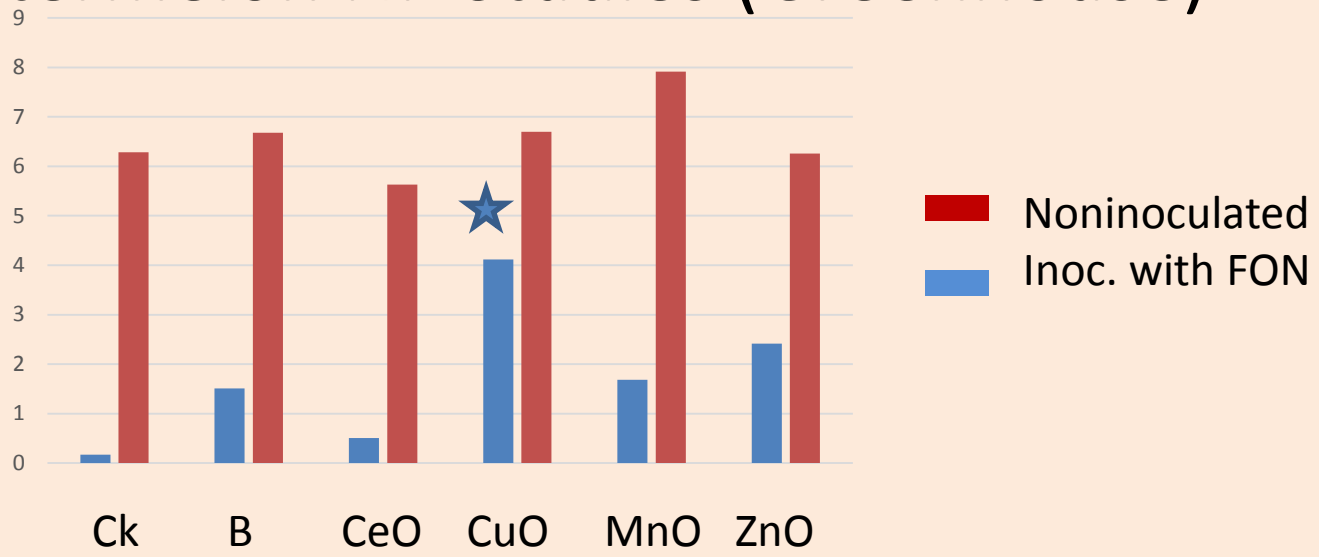
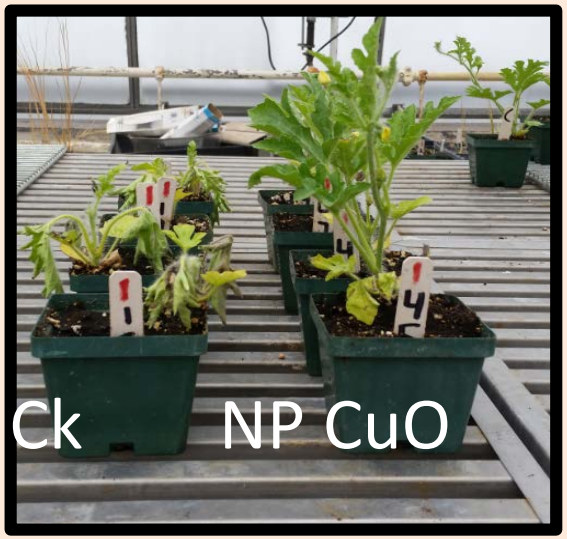
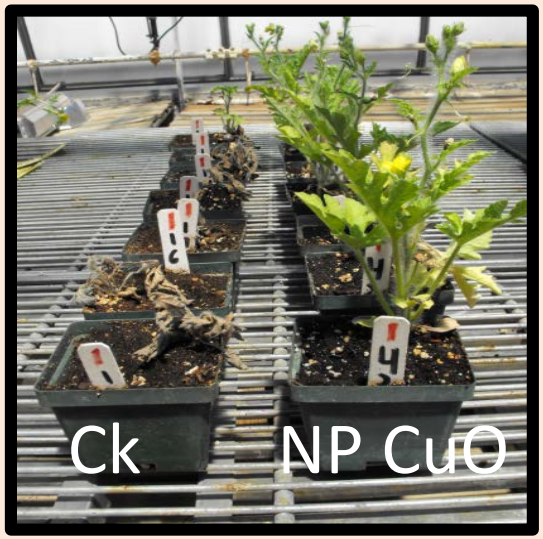
2016 Watermelon NP Studies (Greenhouse)

Fresh weights





July 13

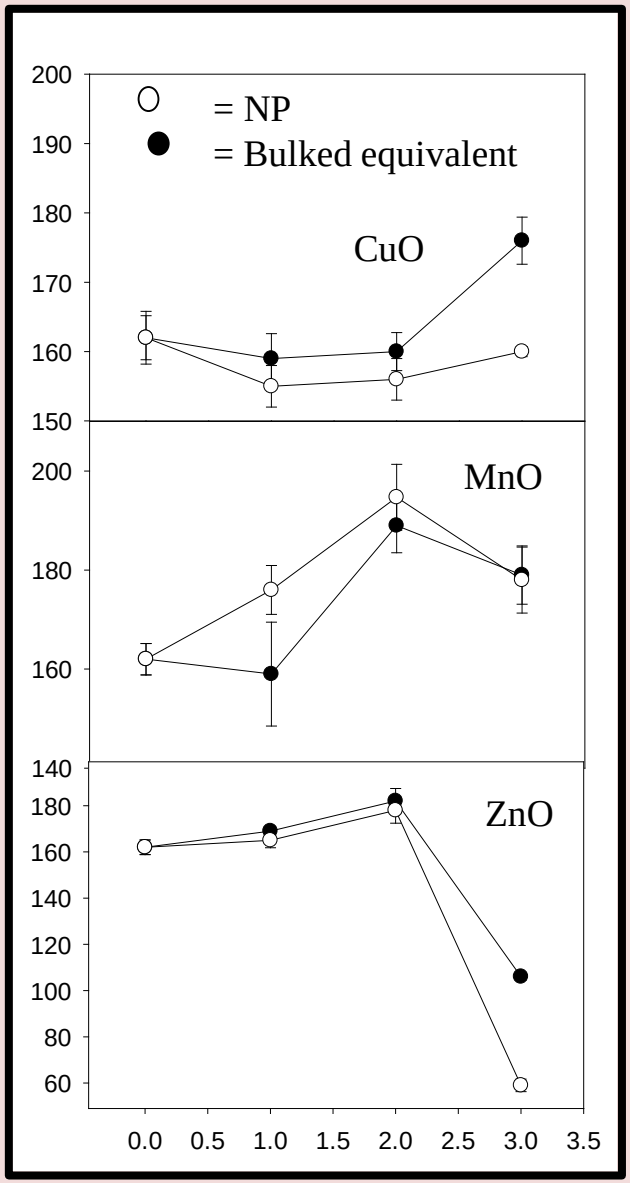


July 21

Field studies 2016

Treatments

1. Control
2. B NP
3. CeO NP
4. CuO NP
5. MnO NP
6. ZnO NP



The effect of nanoparticle (NP) or bulked equivalent rates (Log concentration) of CuO, MnO, or ZnO on the integrated values of the radial colony expansion of *Fusarium oxysporum* on 25% potato dextrose agar over three time points.

Error bars represent the standard error of the mean.

Conclusions

- Treating watermelon with NP of CuO promotes growth, yield and may suppress Fusarium wilt of watermelon.

- Season long effects were observed in 2015 following applications to young transplants.

Conclusions

- Treating seedlings of eggplants and watermelons with NP of CuO promotes growth and yield.

- Season long effects were observed following single or double applications to young transplants.

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- USDA AFRI Grant

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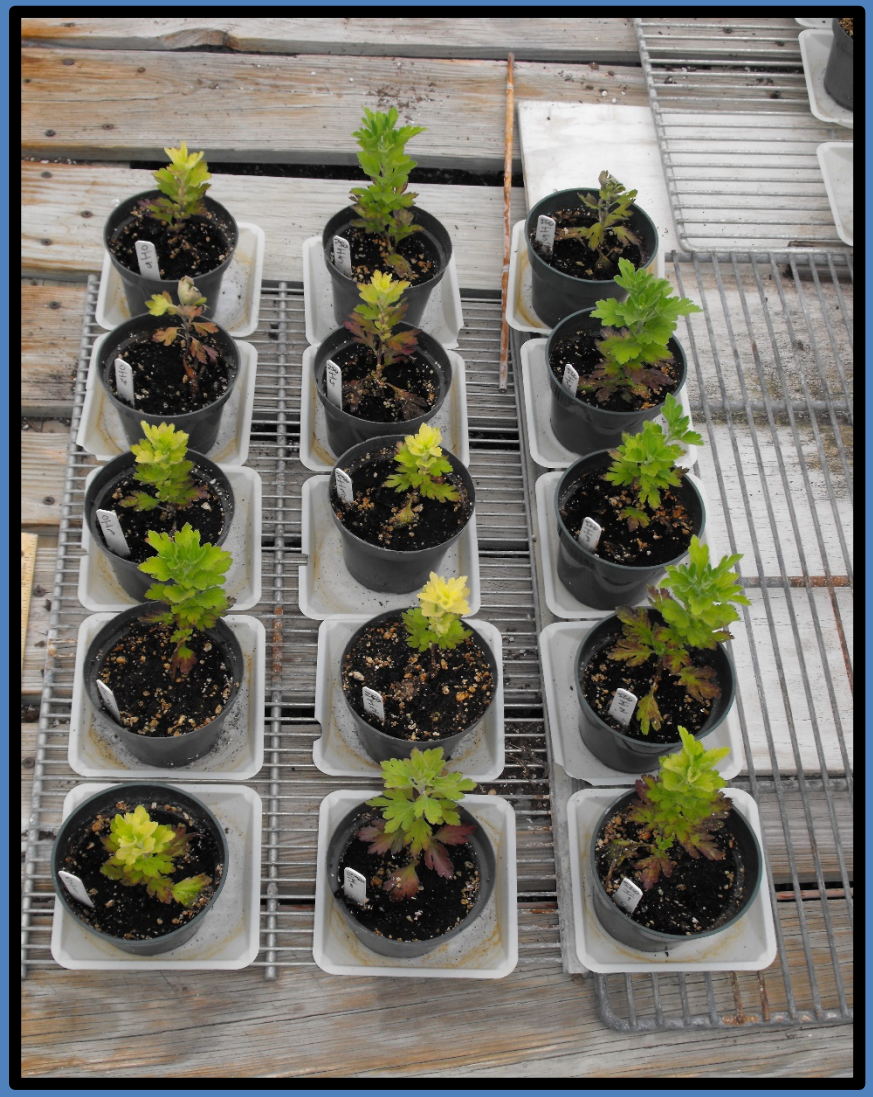
Questions

Foliar application of CuO NP

Pythium aphanidermatum On Chrysanthemum



Control CuO 250 ppm CuO 500 ppm