Vegetable benefits and disease control of nanotechnology

UConn Extension’s 2023 Vegetable & Small Fruit Growers’ Conference
January 4, 2023

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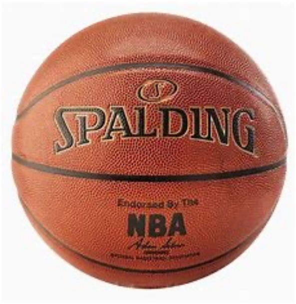
What are nanoparticles ? (1 to 100 nm)



- Elements behaved differently at the Nano scale.
- The small size allows for movement in plant tissue.
- Large surface area allows for dissolution and release of metallic ions over long periods.
- Phytotoxicity not observed.
- Superior to chelated salts.

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Why Nanotechnology ? Declining Global Food Security!!!

- ➢ Current estimates are that food production will need to increase by 70-100% by 2050 to sustain the population.
- ➢ Negative pressure from a changing climate and a loss of arable soil.
- ➢ Up to half or more of the fertilizers applied does not reach plant.
- ➢ Nanotechnology could advance newer fertilizers that require less product and less run-off.
- ➢ Nanotechnology can play a significant role in micronutrient deficiencies and plant health.

Science July 2020

PNAS

Opinion: To feed the world in 2050 will require a global revolution

Paul R. Ehrlich[a,1] and John Harte[b,1]

[a]Department of Biology, Stanford University, Stanford, CA 94305; and [b]Energy and Resources Group, University of California, Berkeley, CA 94720

Achieving universal food security is a staggering challenge, especially in a world with an … (and especially in combination) impede attempts to achieve progressive and effective policies … feed humanity makes the prospects seem slim for making the projected 9.7 billion population food-secure and healthy in 2050, and perhaps billions more beyond that (5).

Major Challenges

Humanity now faces severe biophysical con-

PNAS January 2019

Decline in climate resilience of European wheat

Helena Kahiluoto[a,1], Janne Kaseva[b], Jan Balek[c,d], Jørgen E. Olesen[e], Margarita Ruiz-Ramos[f], Anne Gobin[g], Kurt Christian Kersebaum[h], Jozef Takáč[i], Francoise Ruget[j], Roberto Ferrise[k], Pavol Bezak[i], Gemma Capellades[l], Camilla Dibari[k], Hanna Mäkinen[a], Claas Nendel[h], Domenico Ventrella[m], Alfredo Rodríguez[f,n], Marco Bindi[k], and Mirek Trnka[c,d]

Science Aug. 2018

CLIMATE CHANGE

Increase in crop losses to insect pests in a warming climate

Curtis A. Deutsch[1,2*†], Joshua J. Tewksbury[3,4,5†], Michelle Tigchelaar[6], David S. Battisti[6], Scott C. Merrill[7], Raymond B. Huey[2], Rosamond L. Naylor[8]

ACS NANO

www.acsnano.org

EDITORIAL

At the Nexus of Food Security and Safety: Opportunities for Nanoscience and Nanotechnology

In a 2009 report, the United Nations Food and Agriculture Organization (UNFAO) presented the grand challenge "How to Feed the World in 2050", as the number of people worldwide is estimated to grow to 9.1 billion.[1] This increase in … social policies and economic investment and, notably, new technologies.[1] Technologies are needed to enable sustainable and intelligent farming practices as the increased food production is forecasted to be achievable by increasing crop

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Nanotechnology & Micronutrients?

Micronutrients protect roots against plant diseases by activating enzymes to create defense products.

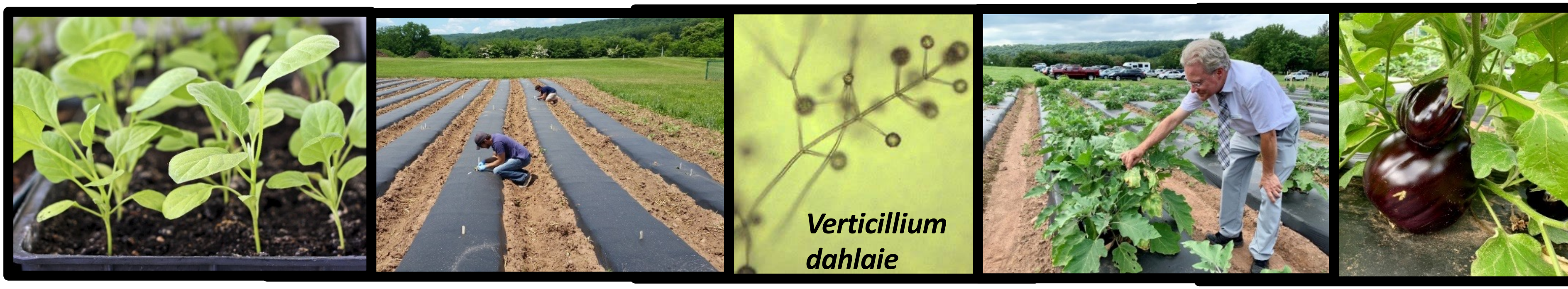
Cu — **activates polyphenoloxidases**

Mn — **activates enzymes in the lignin production**

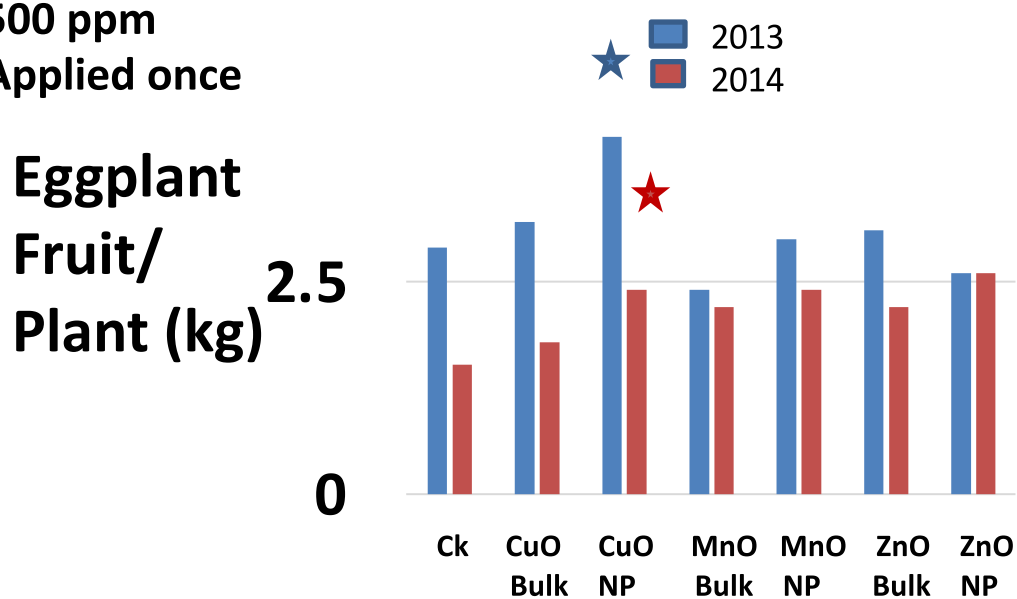
Zn — **activates dismutases, reduces damage from stress (drought, salinity and disease)**

CAES Nanoparticle study on Vegetables

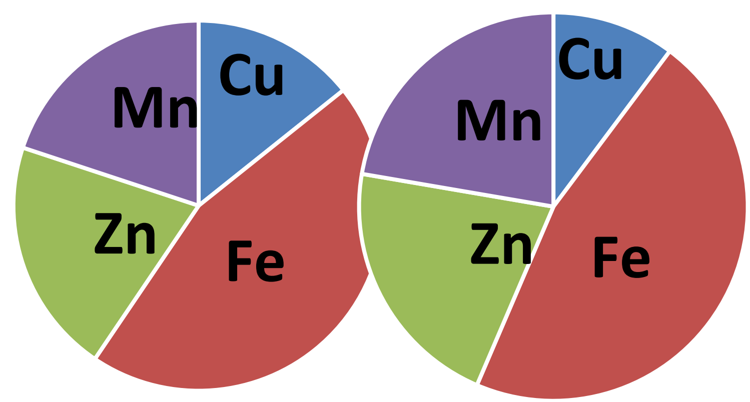
Nanoparticles vs Bulk equivalents: Role of CuO, MnO, or ZnO on Verticillium wilt of Eggplant (*Solanum Melongena)*



500 ppm
Applied once



Fruit composition



Elmer and White (2016) RSC Envion. NANO 3:1072-1079

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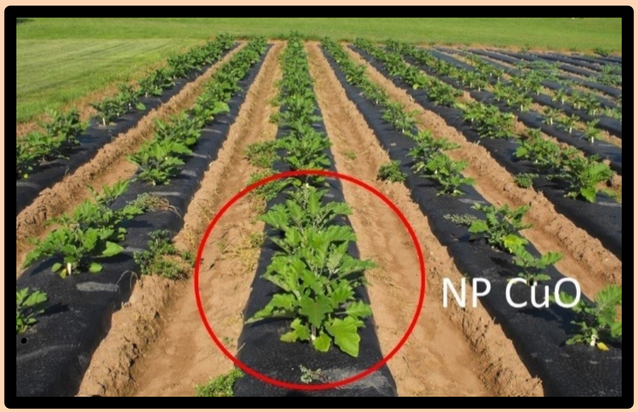
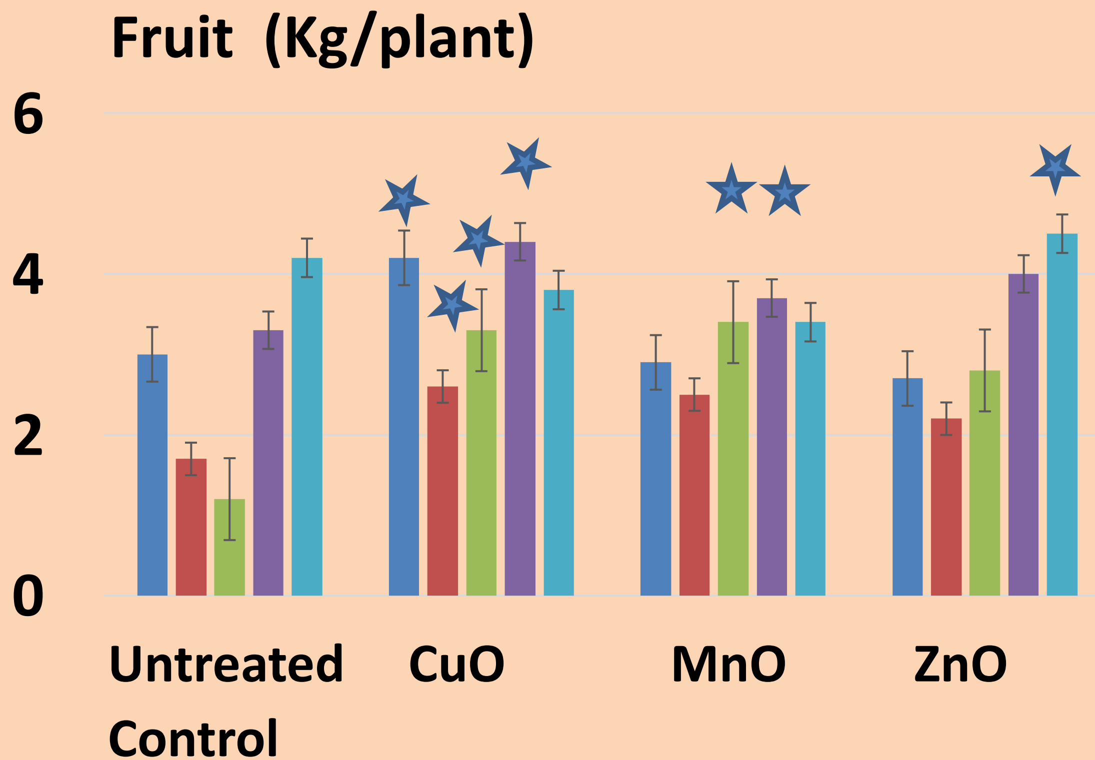
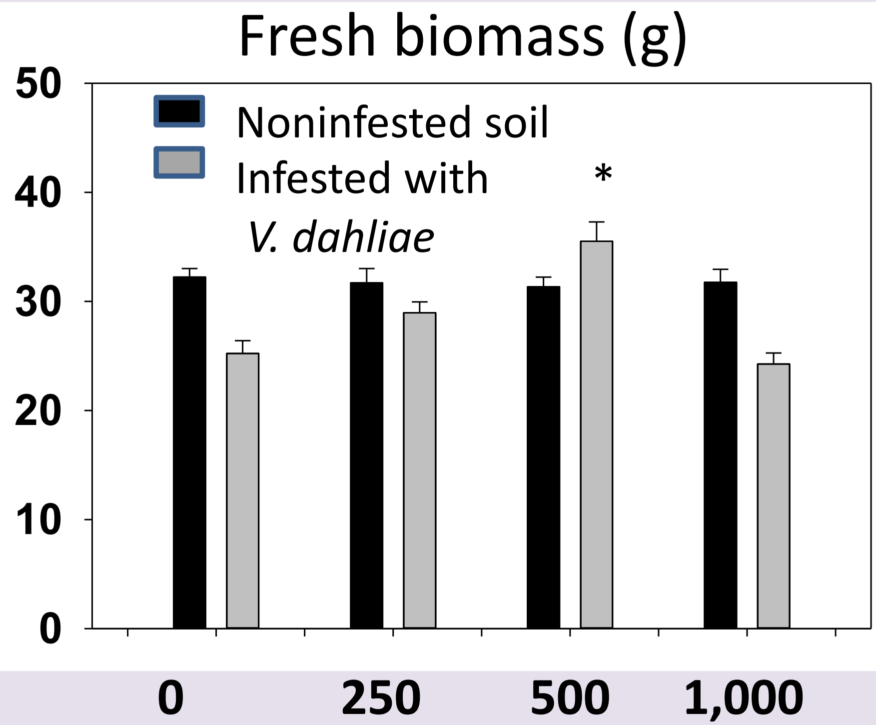
Comparison of Nanoparticles of Copper, Manganese, and Zinc oxides for effect on eggplant yields for 2013, 2014, 2016-2018.



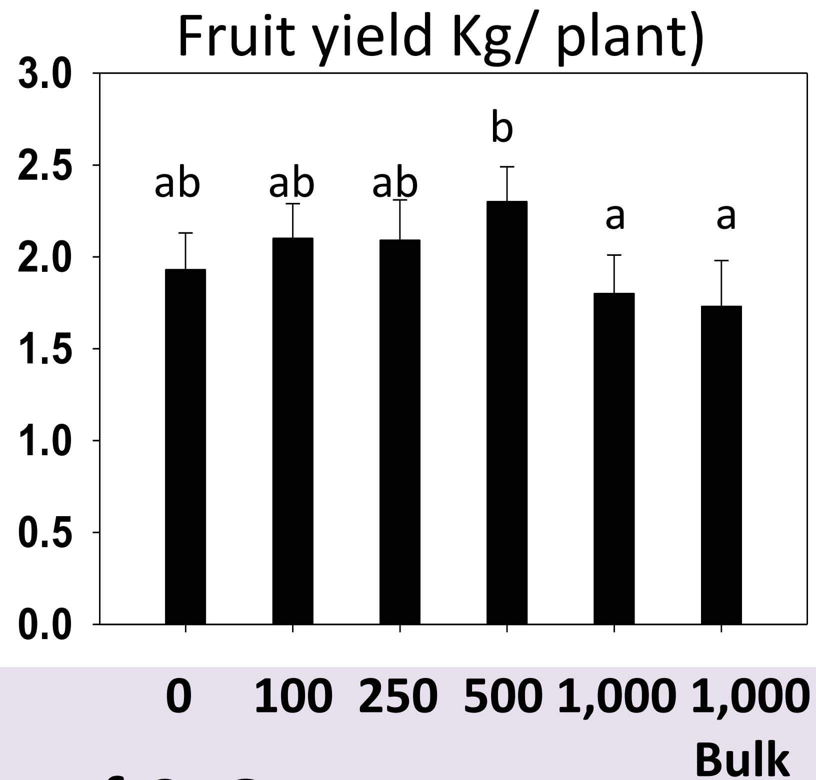


Effect of NP CuO rate

Greenhouse



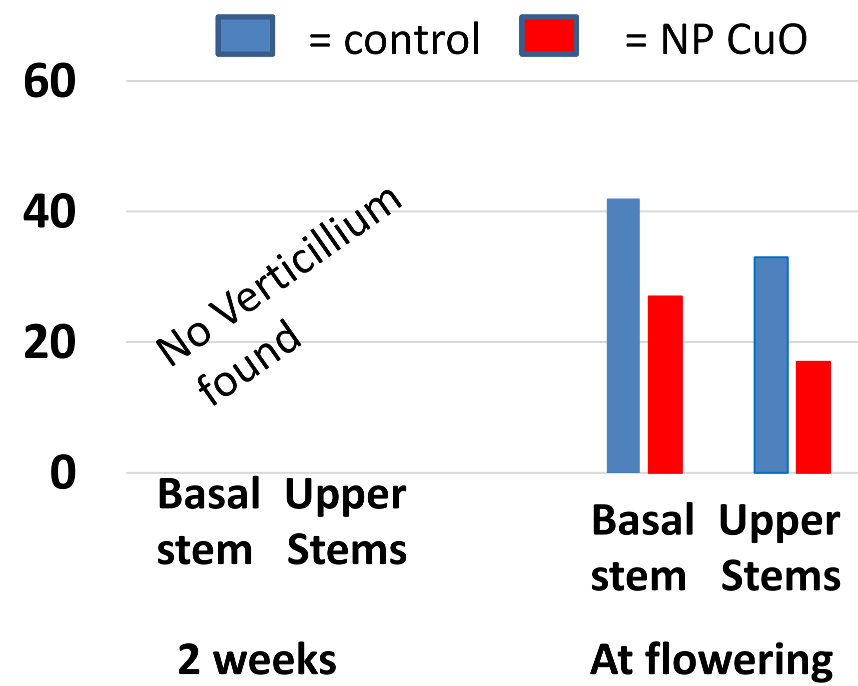
Field



Nanoparticles of CuO

Are the NP CuO affecting the ascent of the fungus into the stem

% colonization by *V. daliae*



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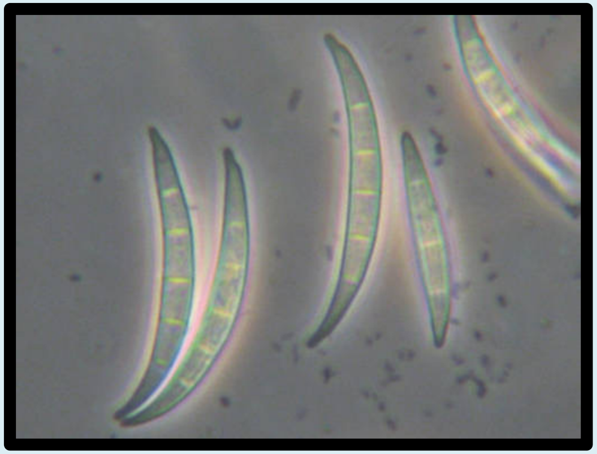
We can calculate that a single foliar application of NP CuO (500 ppm) to young transplant costs < $50.00 per A, but could generate up to $6,300 more profit per acre in New England.

Fusarium Wilt of Watermelon

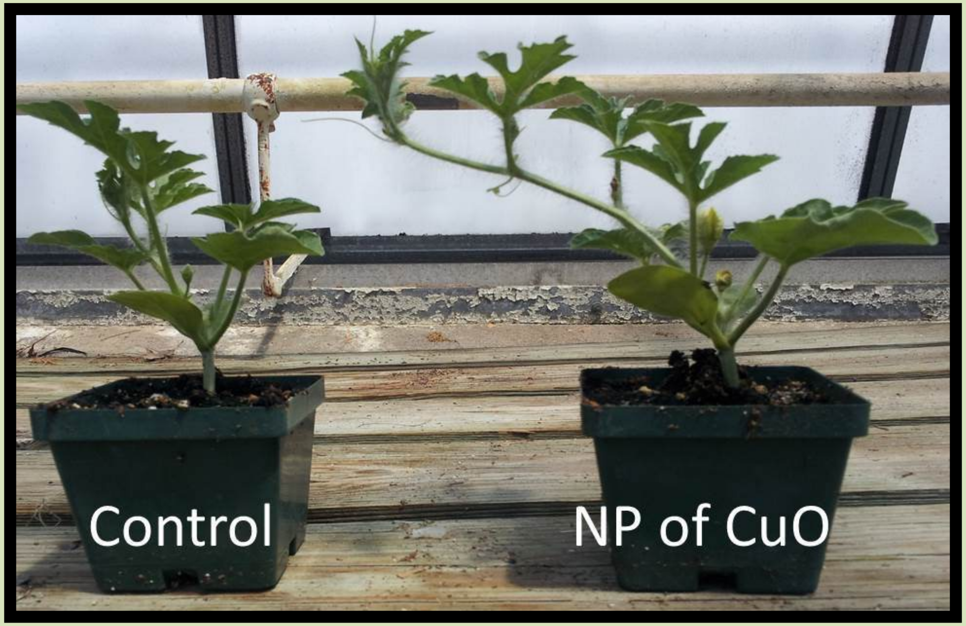
- **Seedless watermelons susceptible**
- **Caused by *Fusarium oxysporum* f. sp. *niveum***



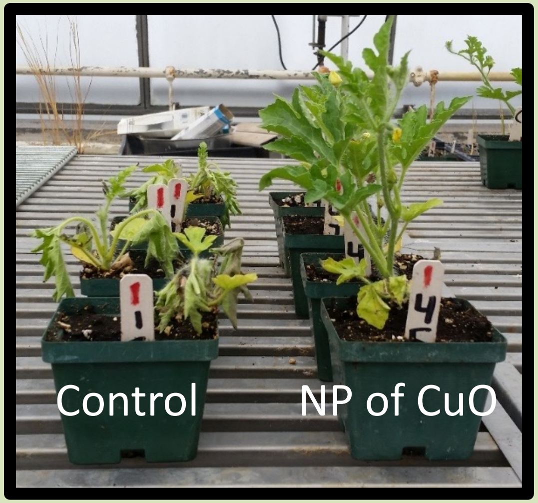
Elmer et al. 2018 https://doi.org/10.1094/PDIS-10-17-1621-RE

Effect of Nanoparticles of CuO on growth and Fusarium wilt of watermelon

Healthy Plant



Inoculated with *Fusarium*



Elmer et al. 2018 https://doi.org/10.1094/PDIS-10-17-1621-RE

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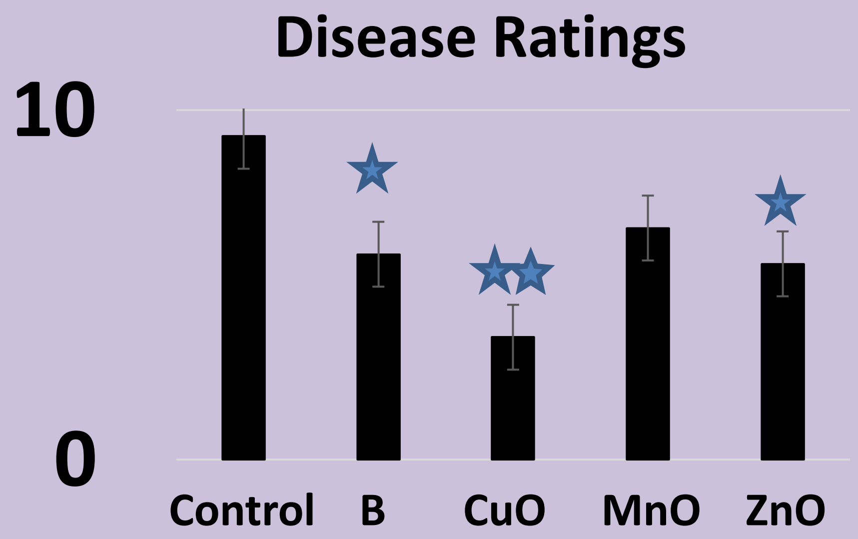
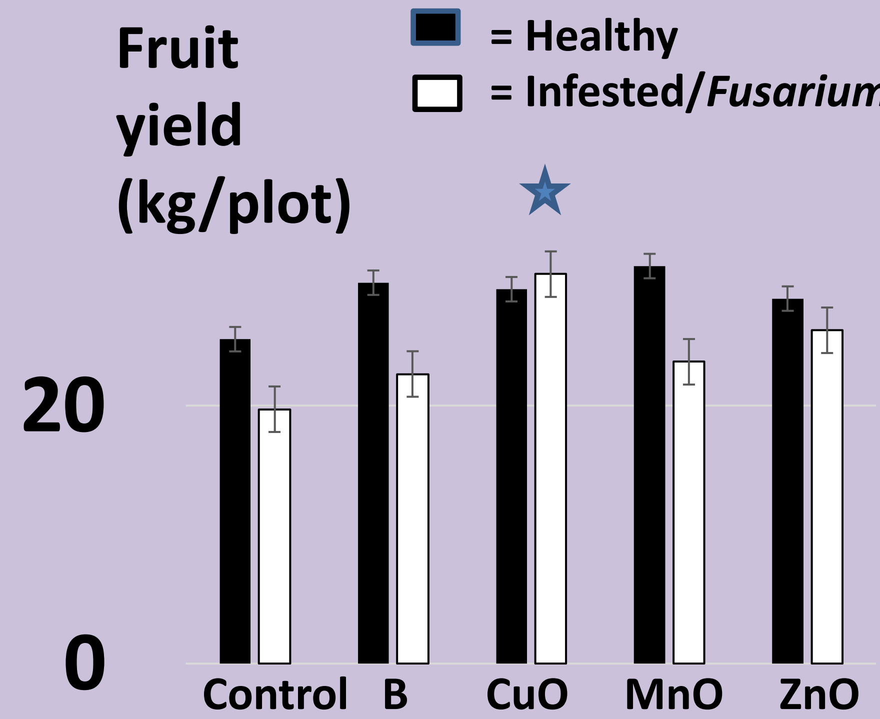
Effect of NP of B, Cu, Mn, and Zn on watermelon yield





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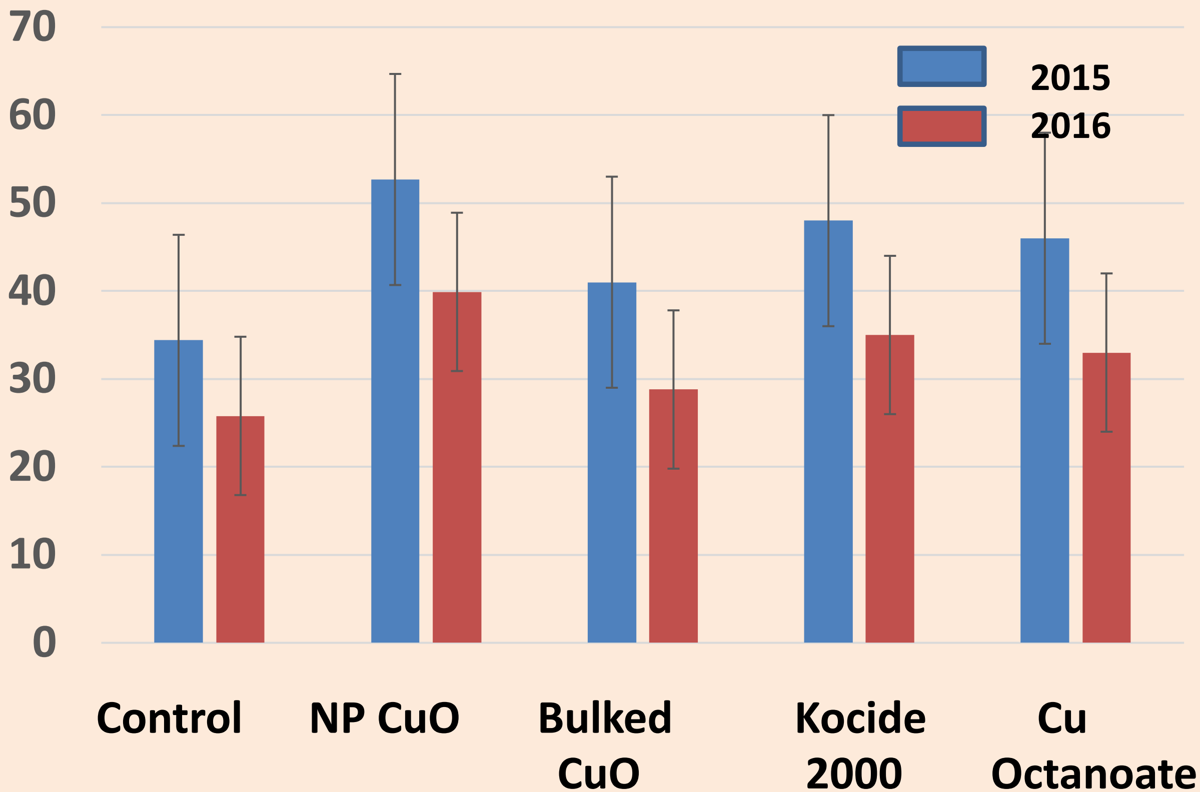
Effect of different sources of Cu

1. Untreated
2. NP CuO
3. Bulked CuO
4. Kocide 2000
5. Cu Octanoate

Watermelon Yield (kg fruit/plot)



Elmer et al. 2018 https://doi.org/10.1094/PDIS-10-17-1621-RE

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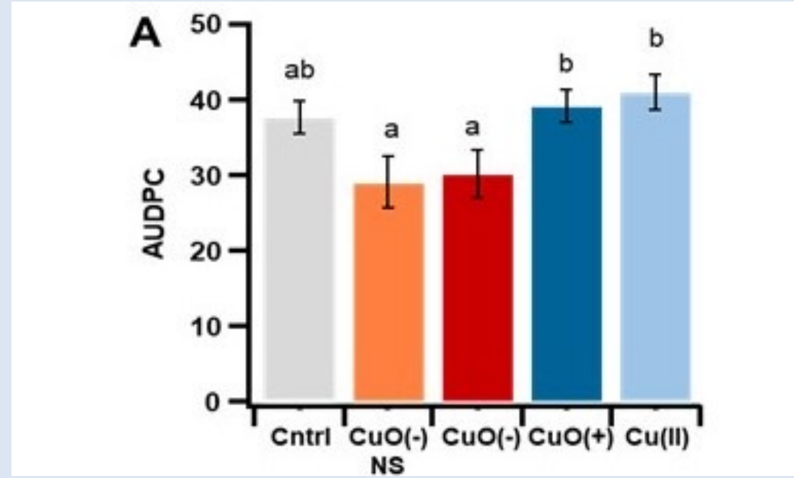
Effect of Cu NP on Fusarium wilt of tomato

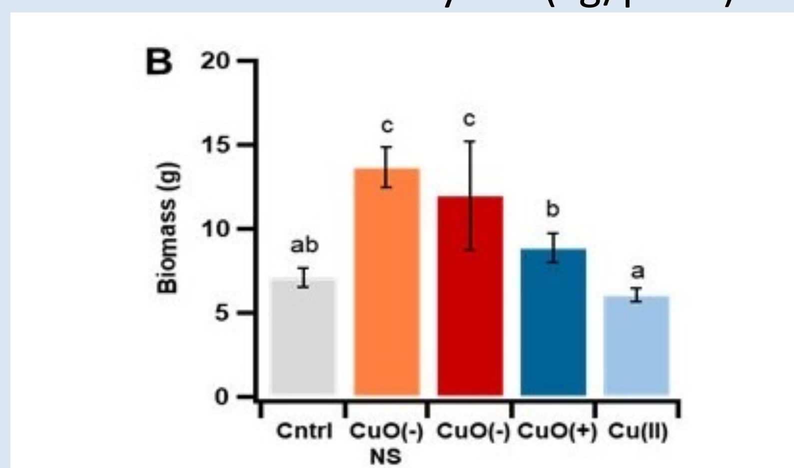
Untreated Control Inoc.	Inoculated w/Fusarium	Treated w/NP Cu	Treated w/NP Cu & /Fusarium

Field studies

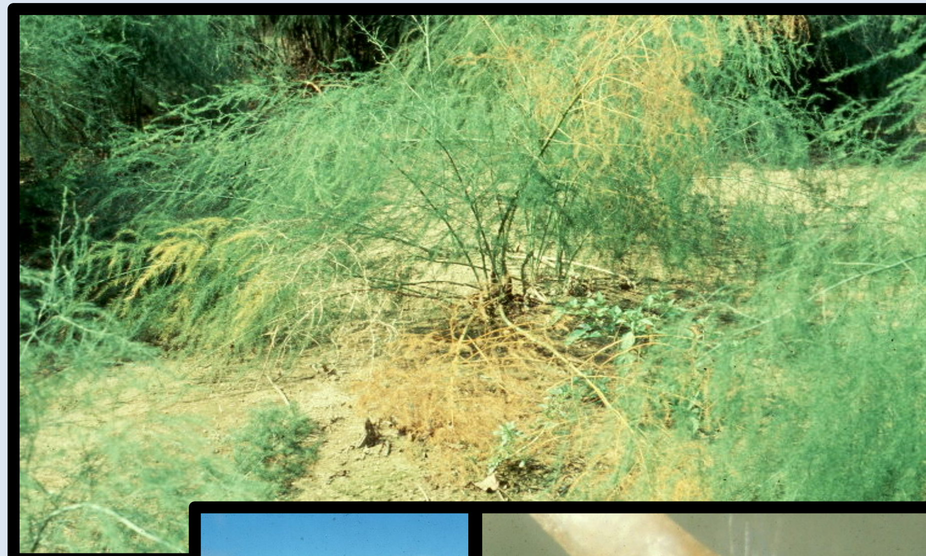
Disease estimates



Tomato yield (kg/plant)



Fusarium Crown and Root Rot of Asparagus



Water (Control)
B NP
CuO NP
MnO NP
MoO NP
ZnO NP

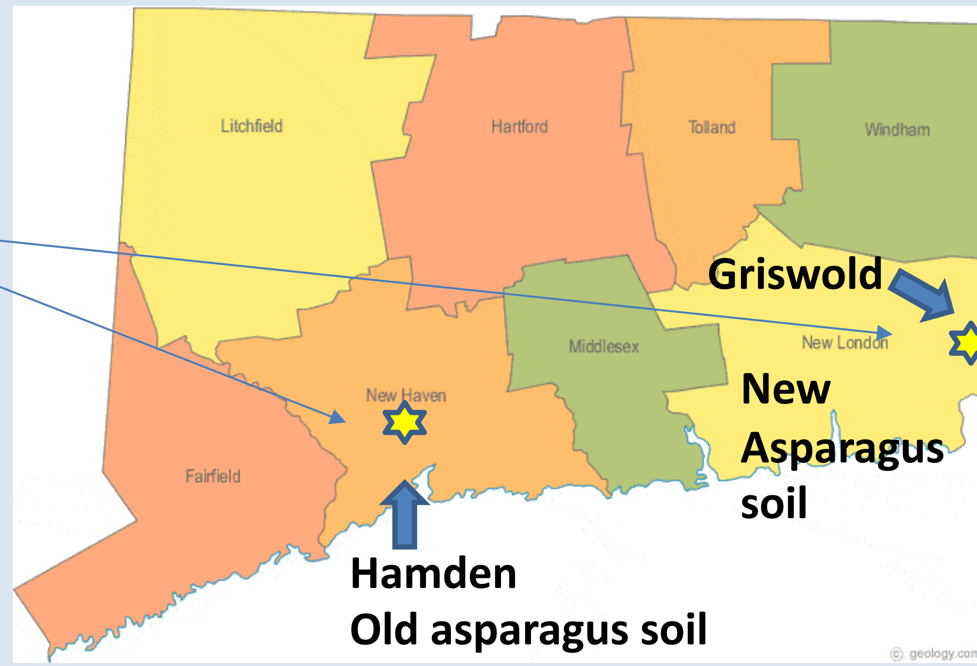
- **Soaked 1 yr crowns (100 ppm for 30 min)**
- **Planted 2018**
- **Harvested 2020 and 2021**

Elmer et al. (2023) Acta Horticultureae (In press)

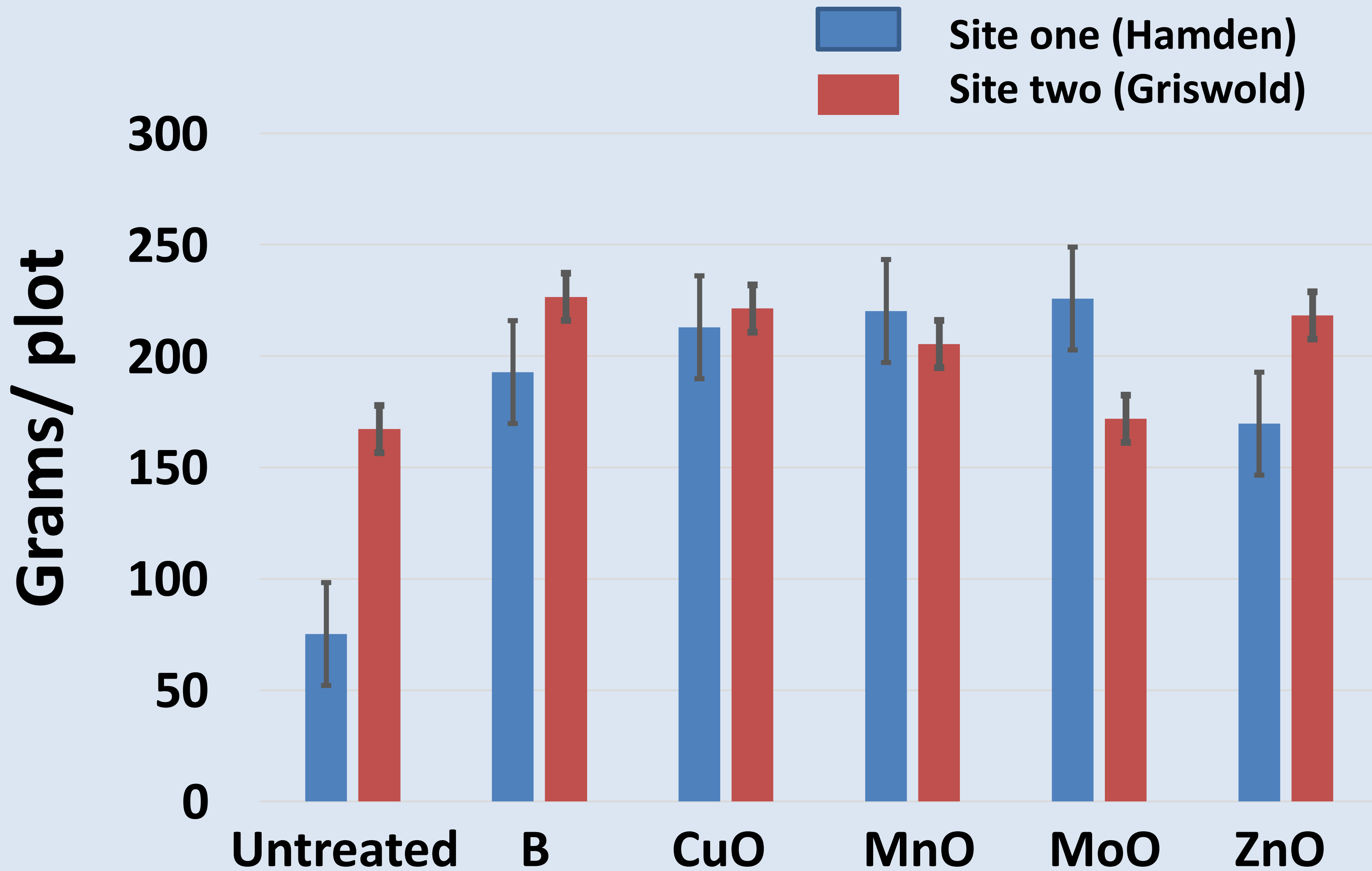
Field studies 2018

Compared NP of B, CuO, MnO, MoO, ZnO to an untreated control

Two locations
Six replicate plots
10 crowns/plot



Marketable yield (Averaged 2020 & 2021



Elmer (2023) Acta Horticultureae (In press)

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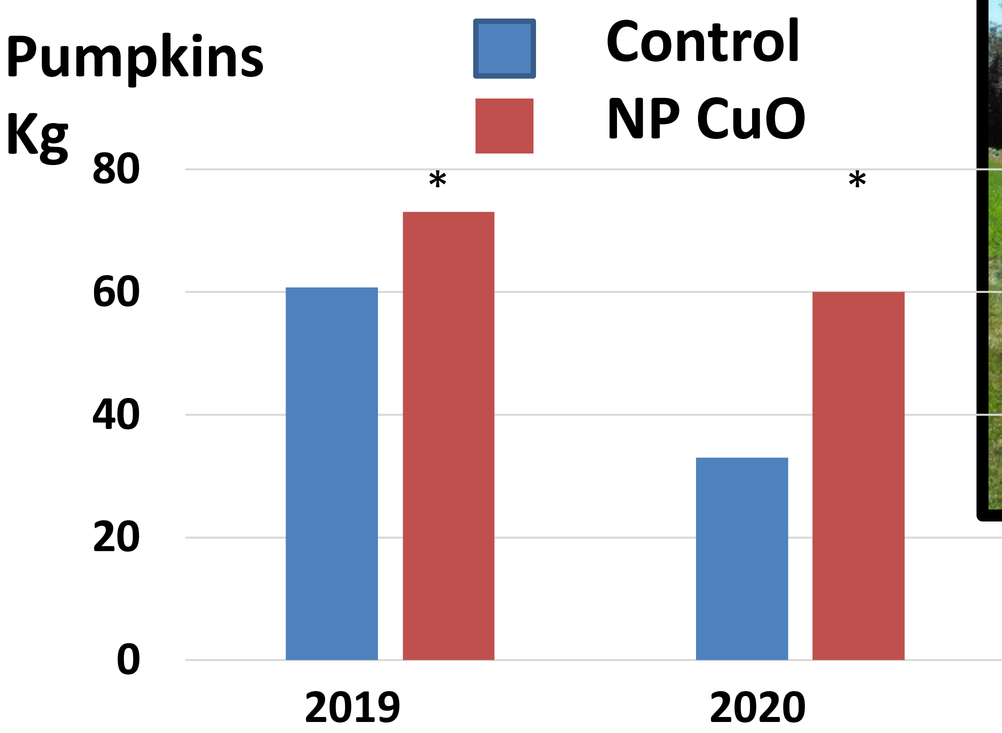
Effect of NP CuO on 2019 & 2020 pumpkin yield On a moderately resistant pumpkin (Gladiator)

Young seedlings treated in the greenhouse (500 µg/ml) then transplanted. No fungicide sprays applied



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Conclusions

- NP of Cu have growth promoting and disease suppressing properties that exceed their larger equivalents or Cu salts.
- The efficacy of NP Cu on a wide range of host plants against various pathogens suggest a general disease suppressing mechanism is operating.
- **Season long effects** were observed following single applications to young transplants.
- Foliar sprays to young plants require minimal product and exposure.

Where do you get NP of CuO

- Can be obtained commercially.
- Consult The CAES about NP vendors, preparation, safety, and methods of application.
- Down the road NP could be made 'on site' by a process called Green synthesis.

[How nanoparticles can help solve the global food crisis | Christy Haynes | TEDxMinneapolis
youtu.be]

Acknowledgements





Peter Thiel

Nubia Zuverza-Mena

Christian Dimkpa

Jorge Gardea Torresdey

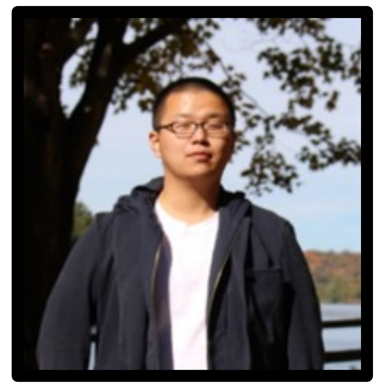
Jason White

CONNECTICUT DEPARTMENT OF AGRICULTURE

USDA NIFA
United States Department of Agriculture
National Institute of Food and Agriculture

NSF

The Center for Sustainable Nanotechnology


Jaya Borgatta

Yu Shen

Chuanxin Ma

Rich Cecarelli Lockwood Farm
Rollie Hannan Lockwood Farm
Rob Durgy Griswold Farm

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Questions