Nanoparticles in Agriculture

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The Connecticut Agricultural Experiment Station

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What is a nanoparticle

- Imagine something so small that it's a million times smaller than the length of an ant.

- Any particle that has at least one diameter less than a 100 nanometers.

How big is a nanometer

- It is one billionth of a yard stick.

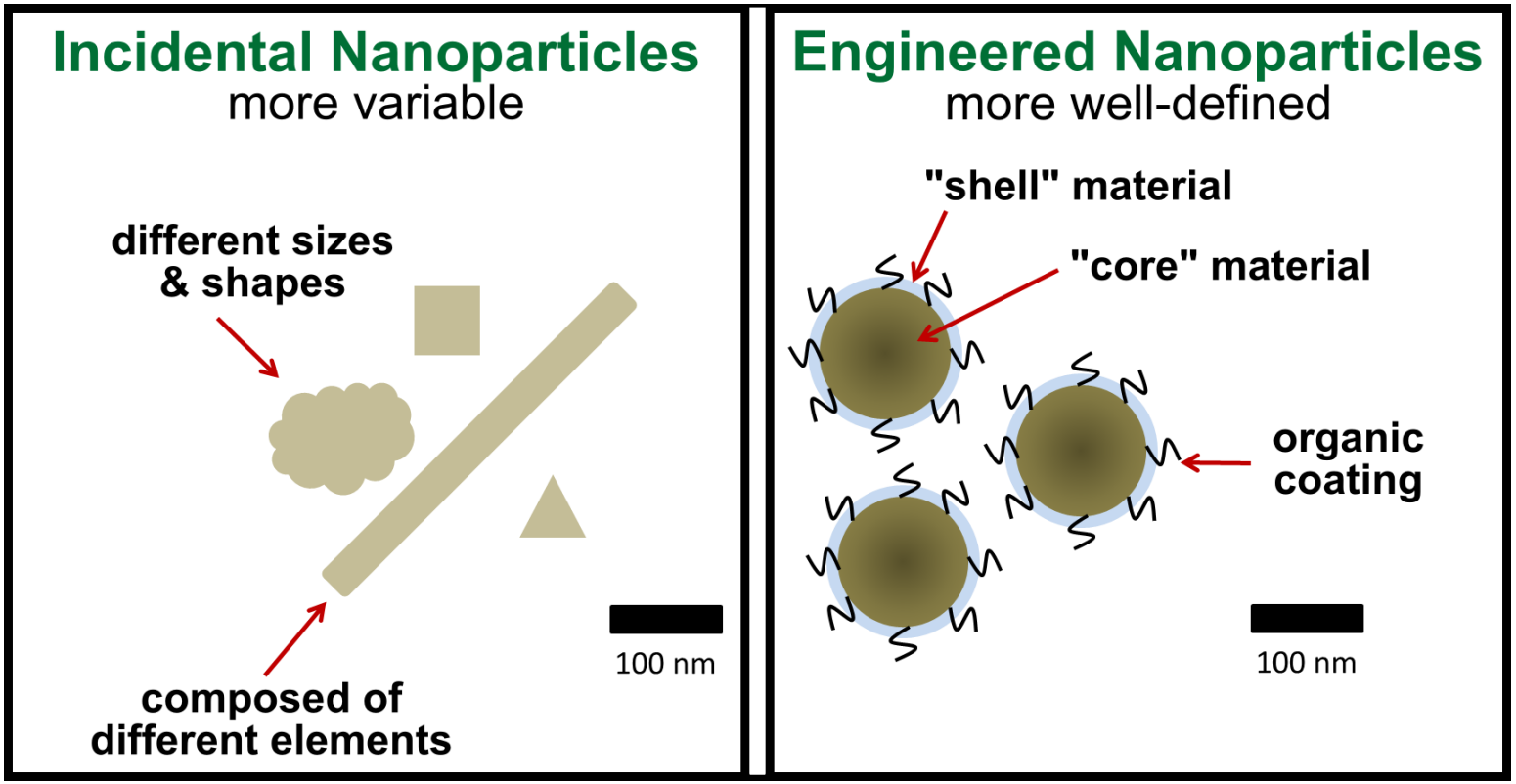
The diameter of the earth is 7918 miles, so a nanometer equivalent (one billionth) would be ½ inch.

Nanoparticles occur naturally

Nanoparticles are produced by:

Volcanic ash, ocean spray, and dust storms

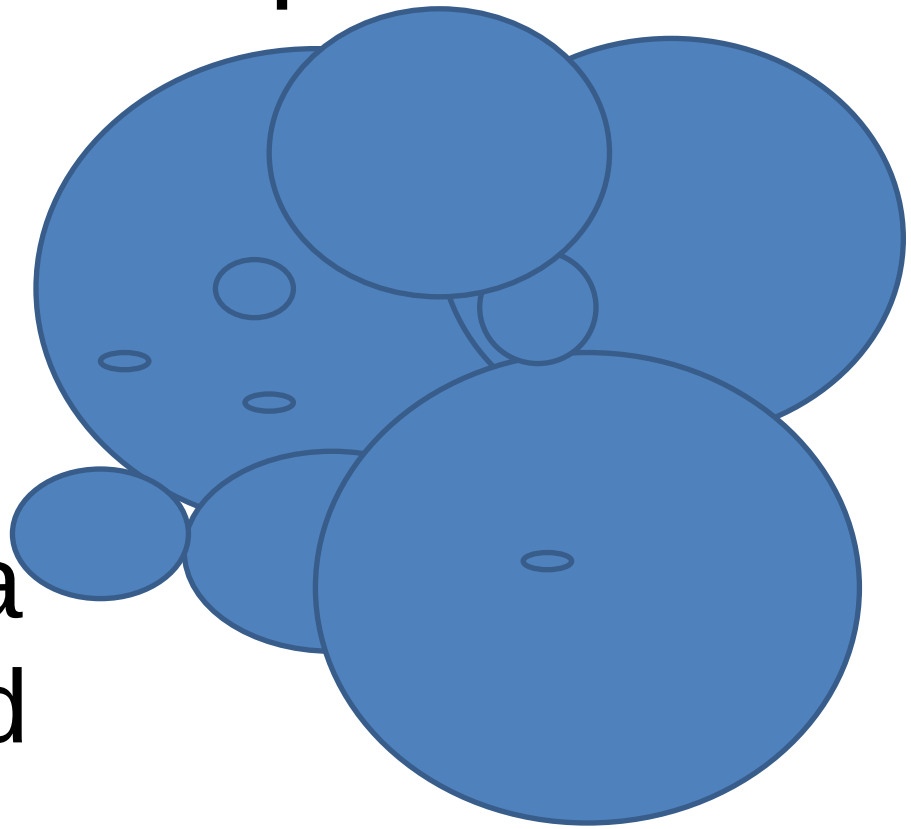
Man made nanoparticles are categorized as “incidental” or “engineered”



Over 1000 engineered nanotechnology products are on the market in the manufacture of:

- Food flavoring
- Perfumes
- Scratchproof eyeglasses
- Stain-repellent fabrics
- Medicines

Nanoparticles behave differently than their bulked equivalents.



They have more surface area.
There is more area for interactions and reactions.

Nanoparticles have unique properties compared to the bulked product

Material	Nanoparticle	Bulked
Copper	Hard	Soft
Gold	Chemically active	Chemically inactive
Silicon	Conductor	Insulator
Titanium dioxide	Colorless	White

Engineered nanoparticles have been used for years in paints and sunscreen

Titanium oxides

Zinc oxides

Do nanoparticles have use in agriculture?

- Could agricultural chemicals applied as nanoparticles be more effective at lower doses?

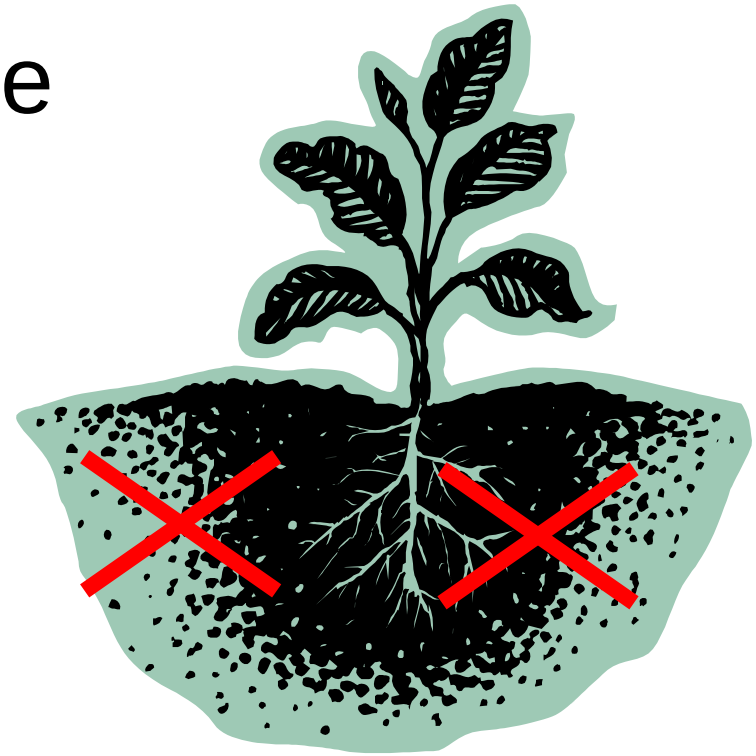
- **Could fertilizers be delivered more efficiently if they were nanoparticles?**

Micronutrients

- Micronutrients like Cu, Fe, Mn, Ni and Zn are required by plants in very small amounts.
- Nutrition is the first line of defense against disease.
- These elements protect roots against soilborne diseases by activating enzymes in defense products.

- **The Problems:**

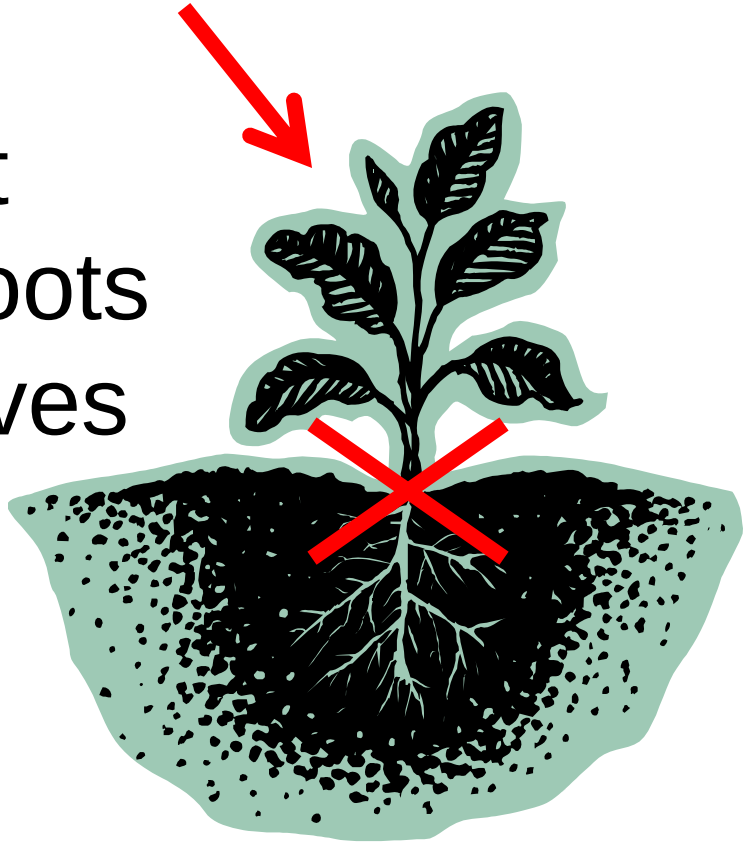
- These metals become less available for uptake by plants in soils that have a pH of 6.5-7.0.



- **The Problems**

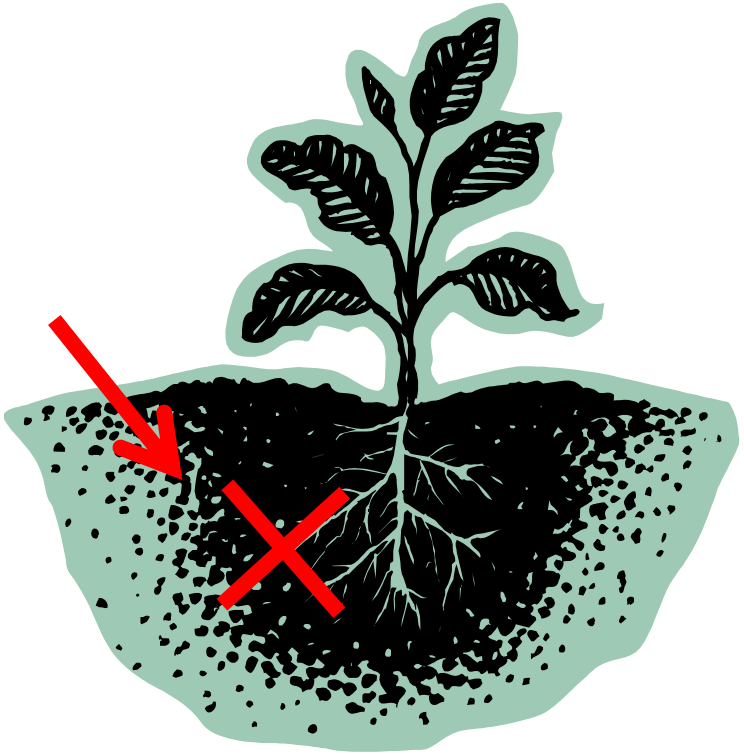
- These metals do not move down to the roots when applied to leaves

  Not basipetally translocated.



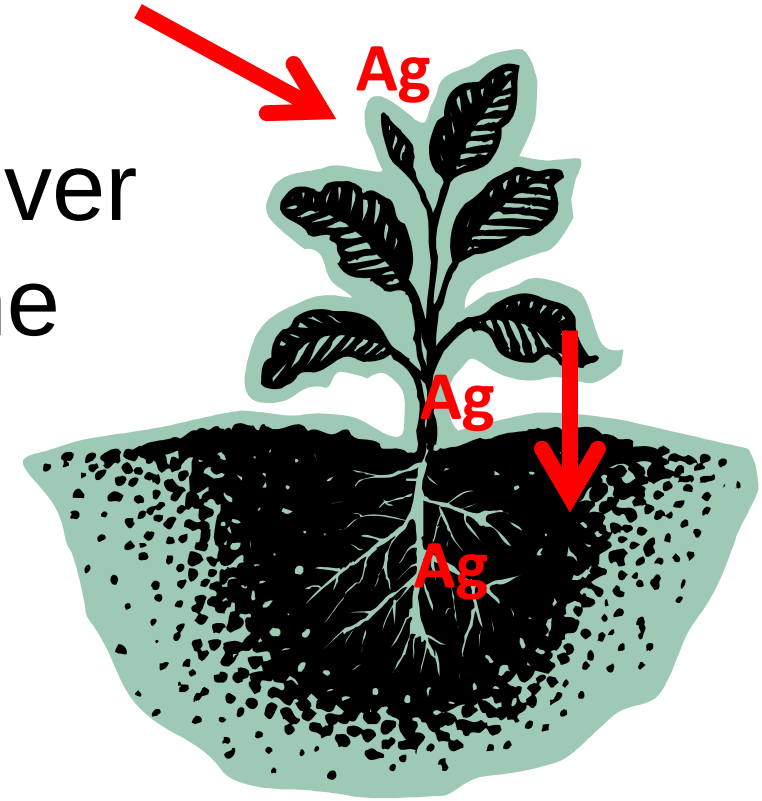
- **The Problems**

- When applied to soil they immediately become unavailable to the plant.



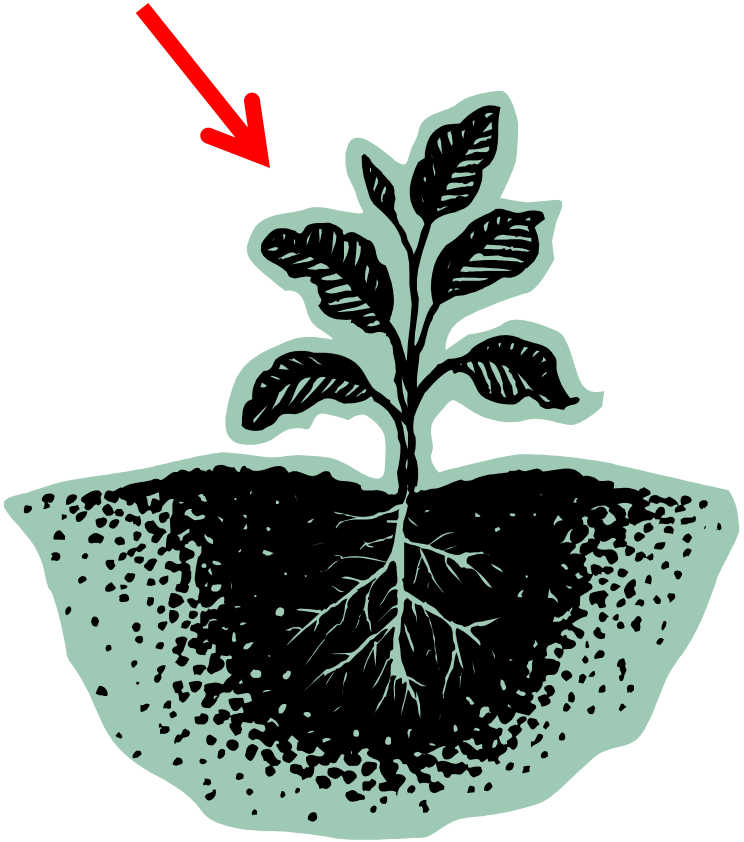
- **The Literature reports**

- Nanoparticles of Silver (Ag) will move to the roots when applied to leaves. The bulked equivalent of Ag did not move down.



• The Hypothesis

Would applying micronutrients as nanoparticles to leaves deliver these metals to the roots where they might suppress root disease?



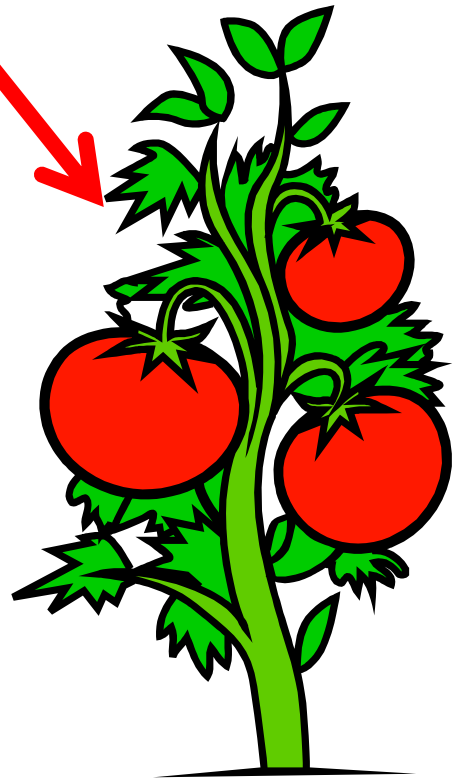
Fusarium Wilt of Tomato

Experiment 1

Would nanoparticles of Al, Fe, Cu, Mn, Ni or Zn increase or decrease Fusarium disease on tomatoes?

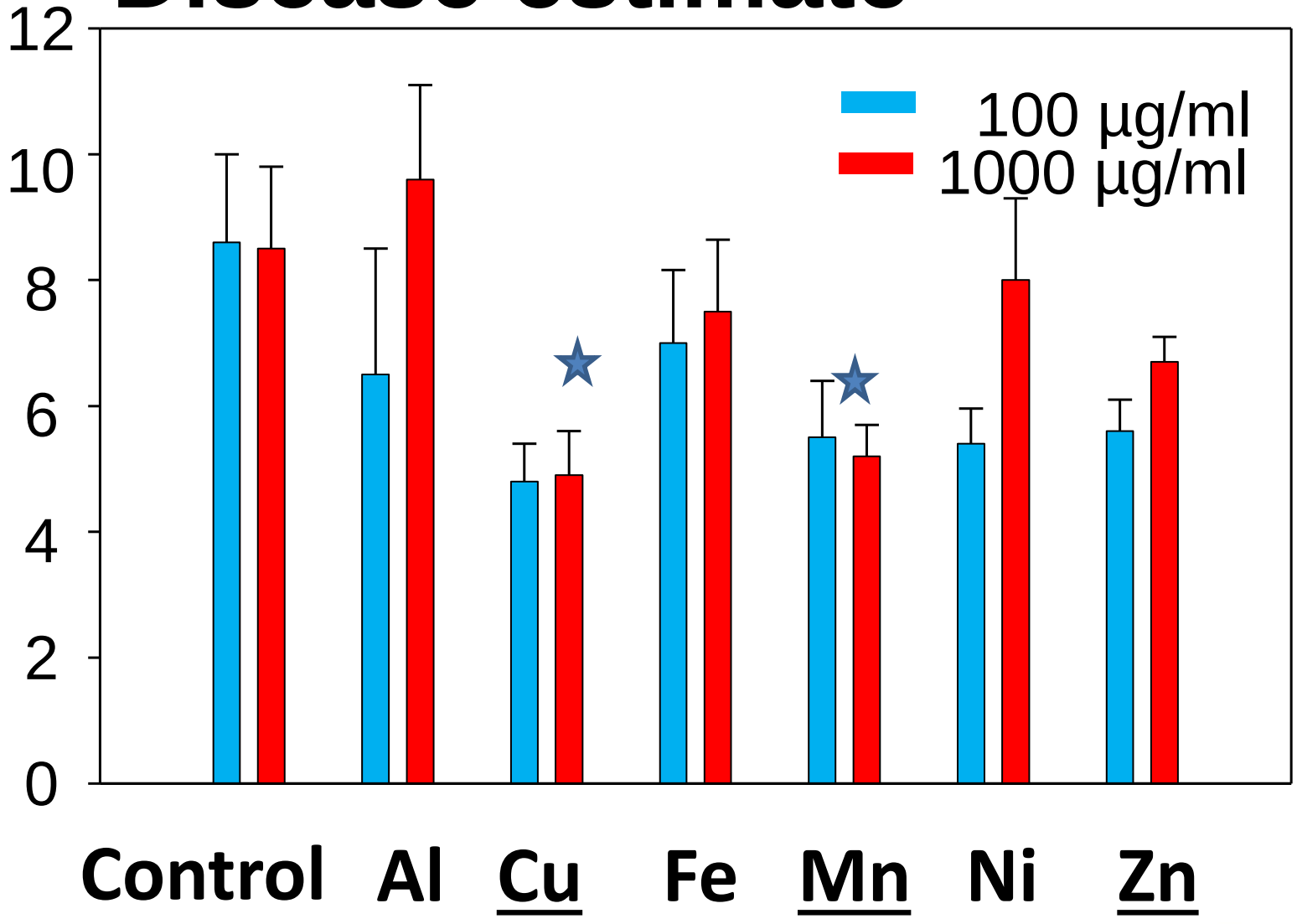
Methods

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* pathogens.

Disease estimate



Experiment 1

- **Conclusions**

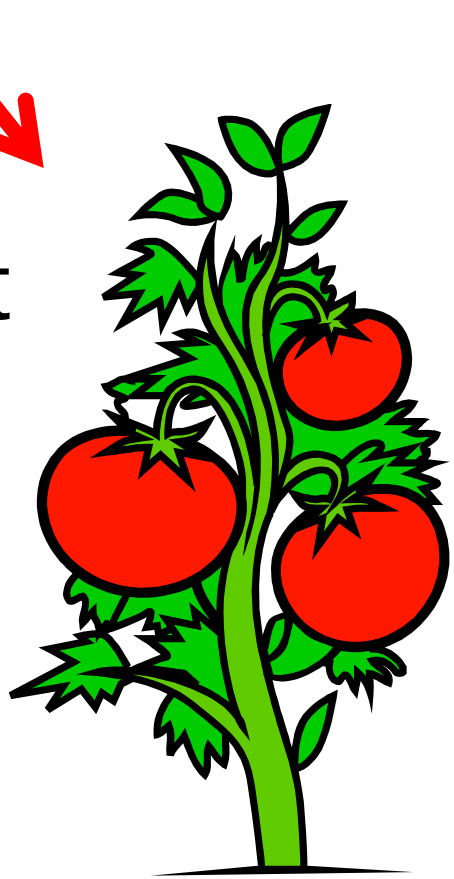
- Treating tomatoes with nanoparticles of Cu and Mn promoted healthier plants.

Experiment 2

- Would nanoparticles of Cu or Mn behave the same as their bulked oxide equivalents?
- Would basipetal translocation occur?

Methods

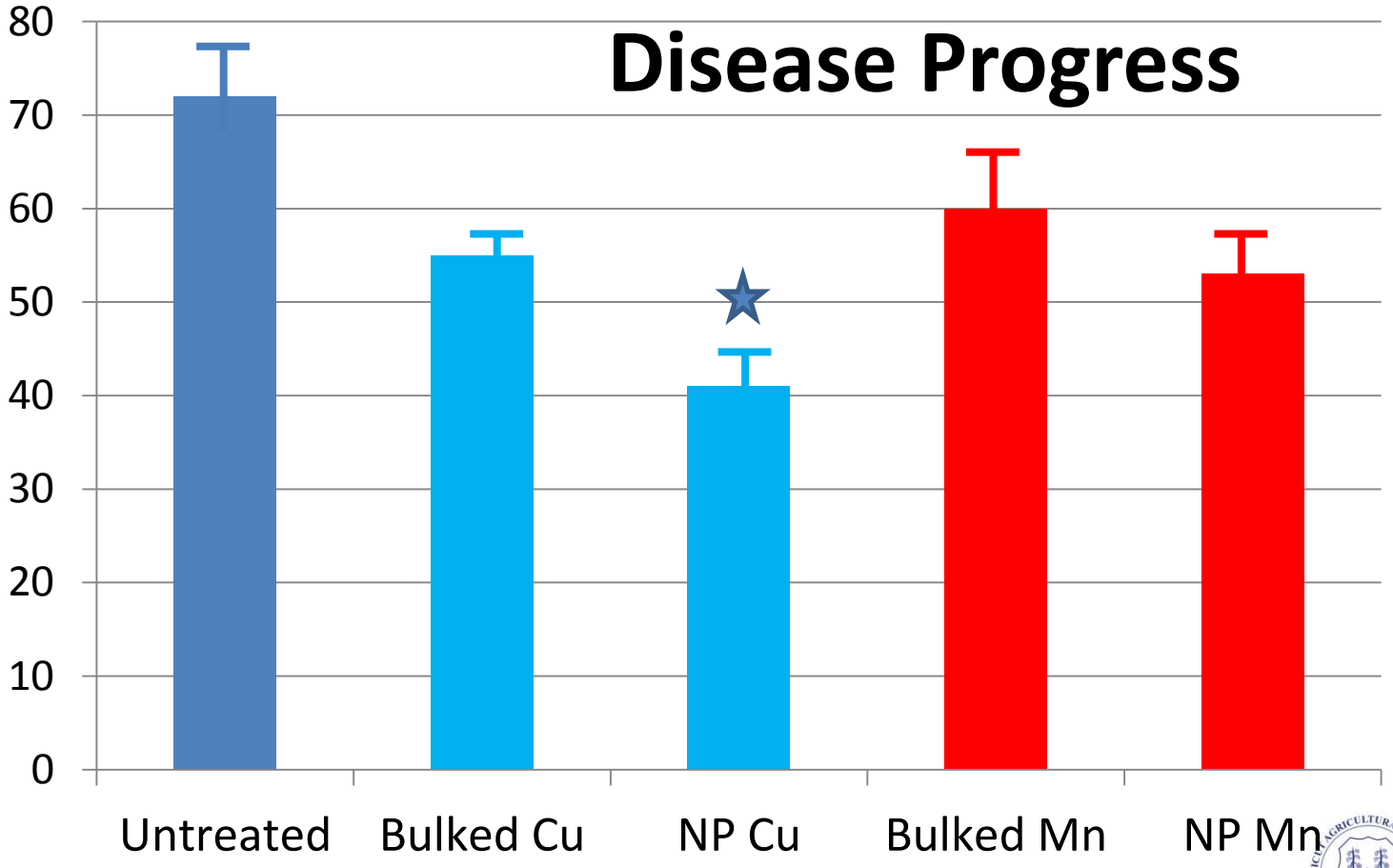
Nanoparticles of Cu or Mn or the bulked oxide equivalent were sprayed onto leaves.



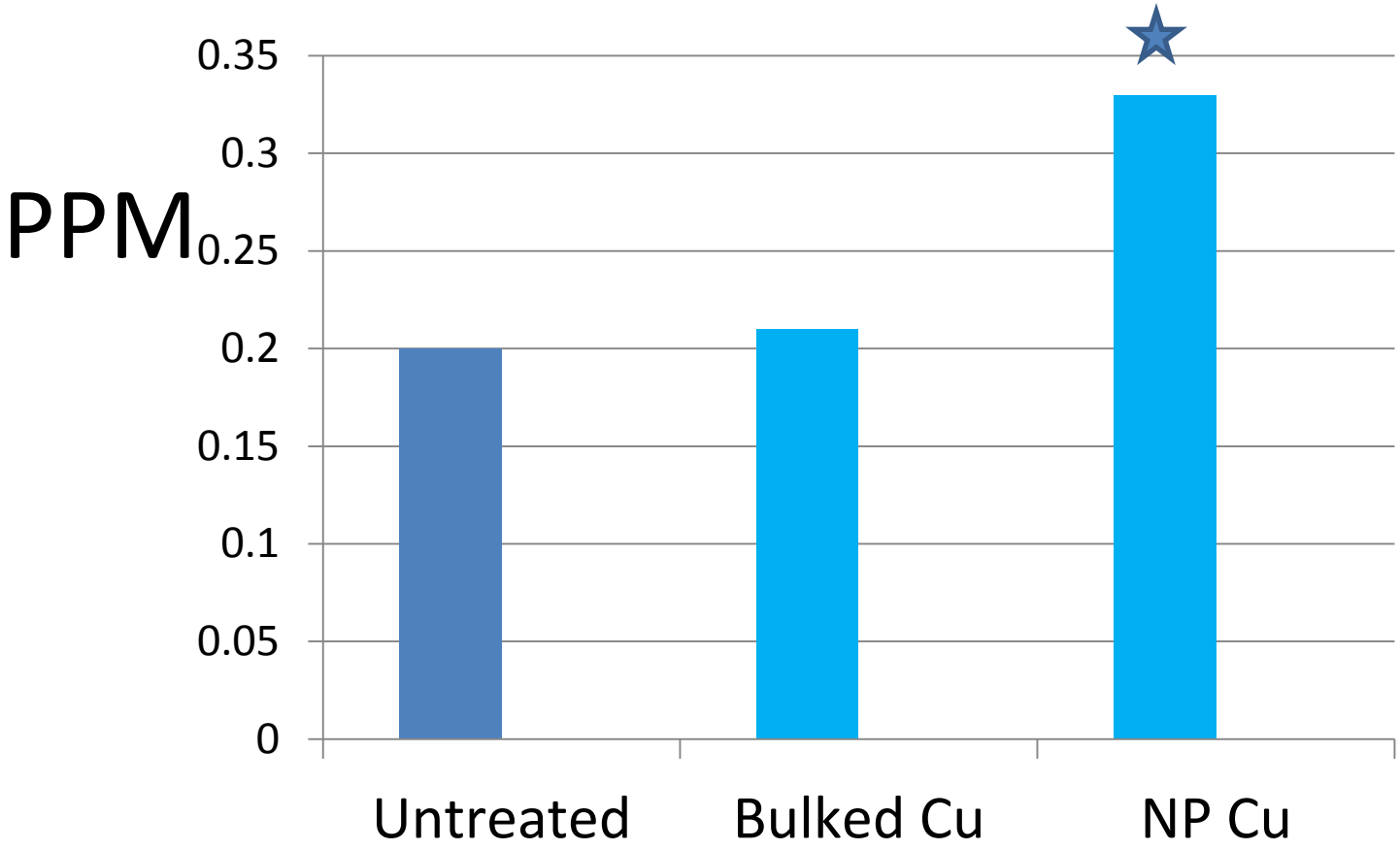
Plants were inoculated with *Fusarium* pathogens

Roots were analyzed for Cu and Mn

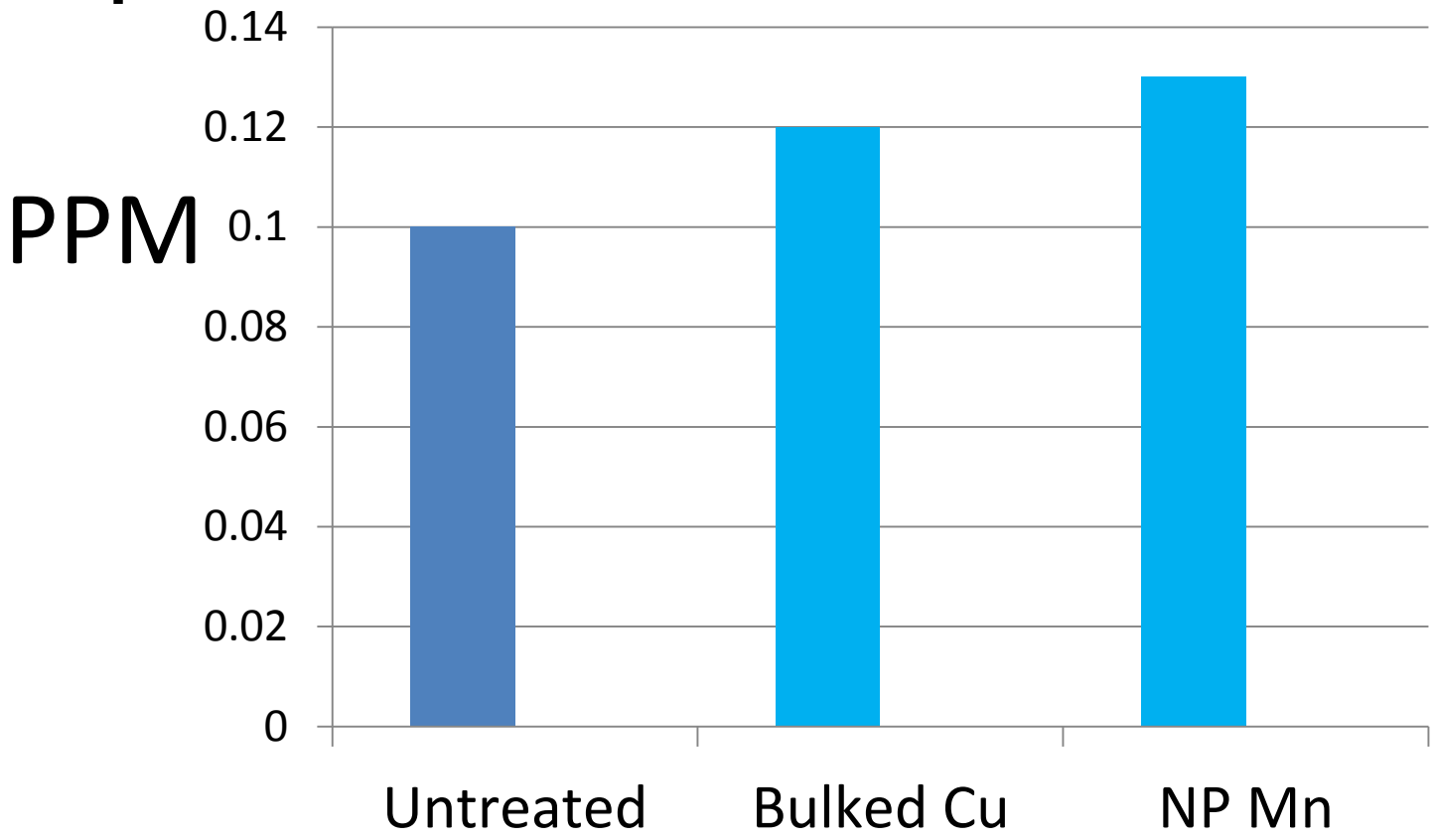
Comparison of Nanoparticles to their bulked equivalent for suppressing disease on tomatoes.



Copper levels in roots of tomatoes treated with Cu nanoparticles or bulked oxide equivalents



Manganese levels in roots of tomatoes treated with Mn nanoparticles or bulked oxide equivalents



Experiment 2

- **Conclusions**

- Nanoparticles of Cu again suppressed disease and performed better than the bulked Cu equivalent.

- Nanoparticles of Cu were detected in the roots suggesting basipetal translocation.

Verticillium Wilt of Eggplant

Experiment 3

- Would nanoparticles of Cu, Mn and Zn suppress Verticillium wilt of eggplant?
- Would they behave the same as their bulked oxide equivalents?
- Would they affect yield?

Methods

Nanoparticles of Cu, Mn, and Zn oxides were compared to the bulked oxide equivalent.

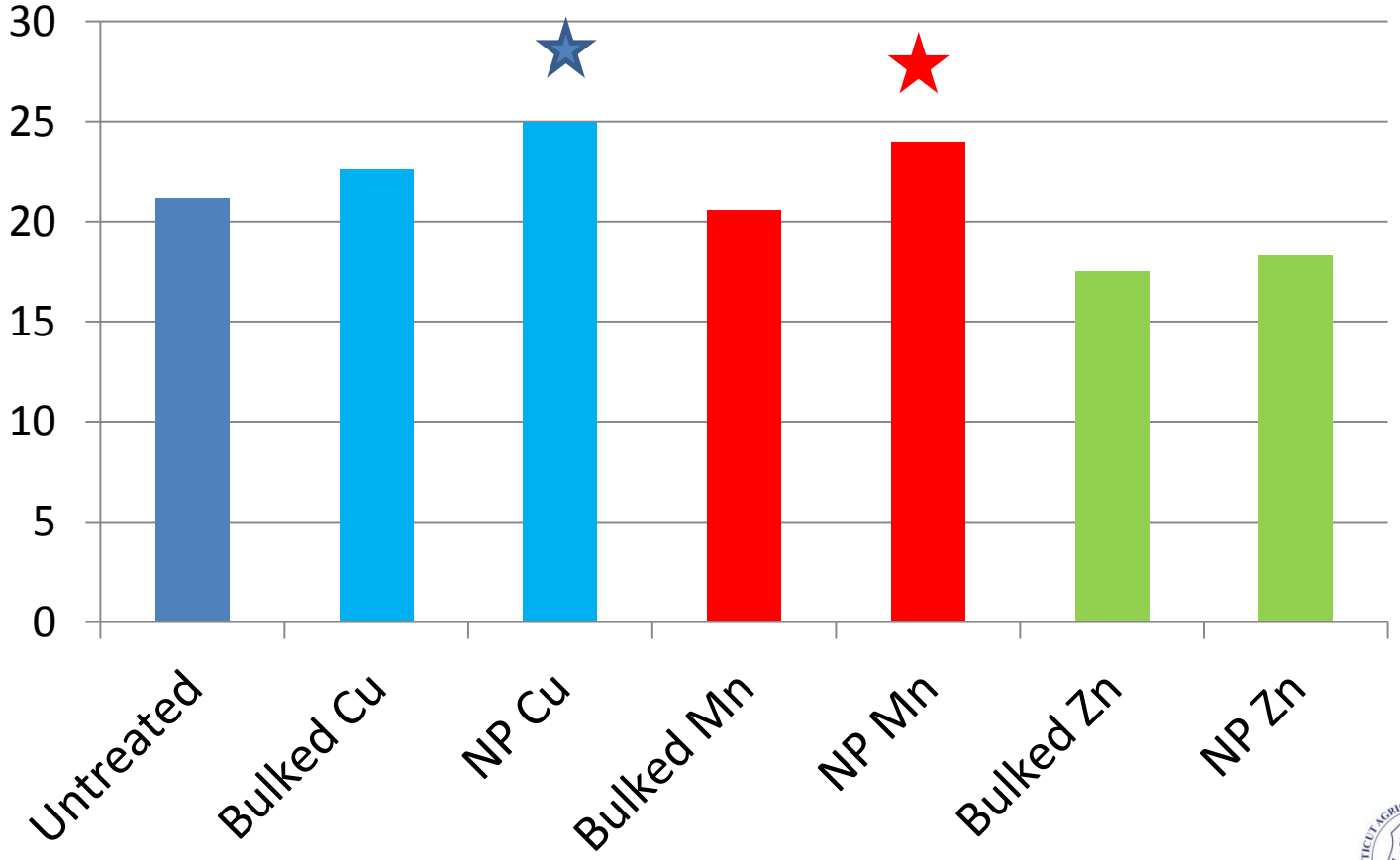
Plants were grown in soil infested with Verticillium.

Growth and yield were measured.

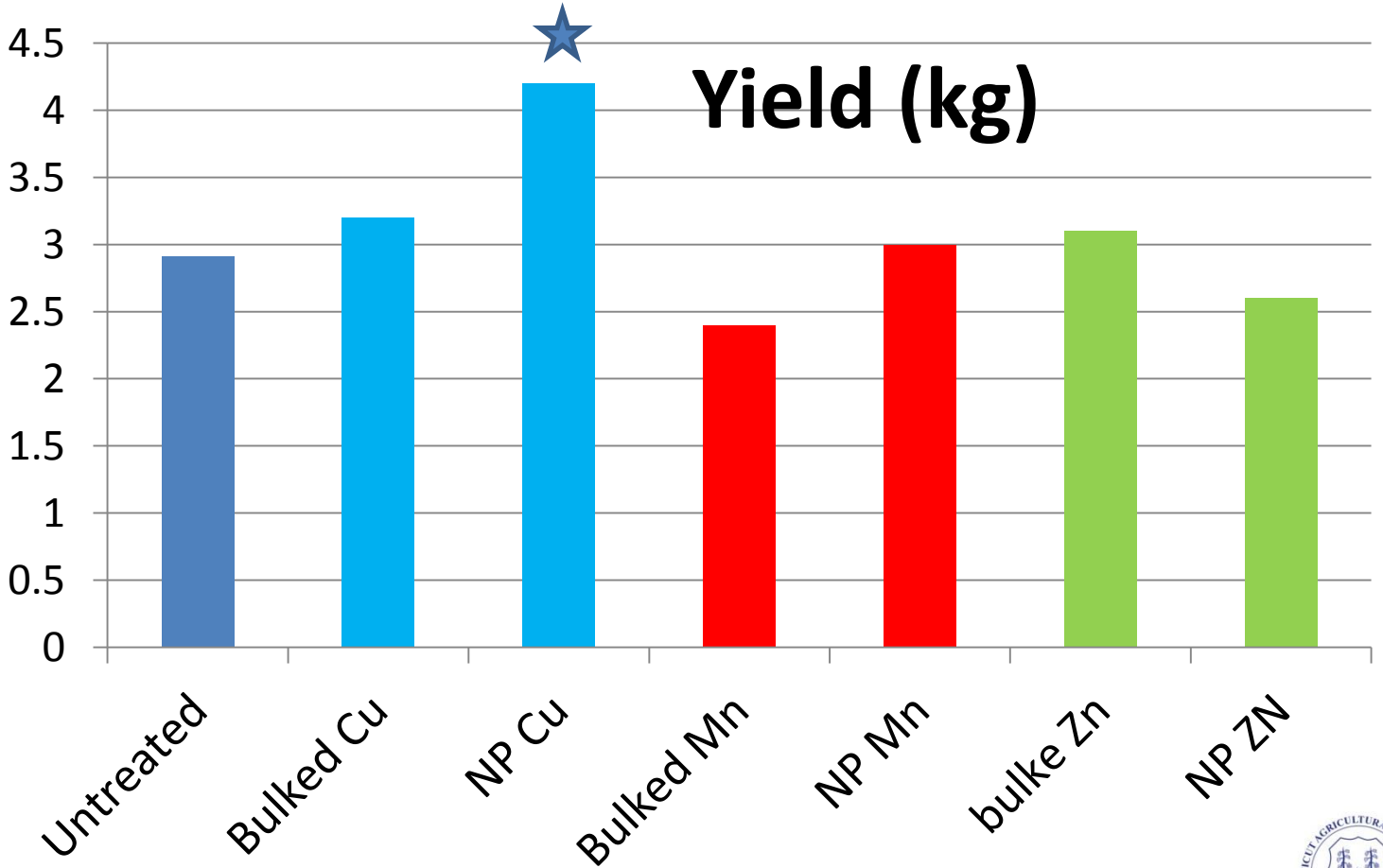
Nanoparticle-Verticillium field trial on Eggplant 2013

Nanoparticle-Verticillium field trial on Eggplant 2014

Comparison of Nanoparticles to the bulked equivalent on the plant canopy development of eggplants with Verticillium wilt



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



Experiment 3

- **Conclusions**

- Nanoparticles of Cu and Mn improved eggplant growth more than their bulked equivalents, but only nanoparticles of Cu increase yield.

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

Summary

- Nanoparticles can have positive and negative effects on plants depending the element and rate.

- Copper nanoparticles appear to have benefit in suppressing soilborne diseases.

Summary

- The mechanism for disease suppression may be associated with the greater basipetal translocation with nanoparticles from leaves to the roots.

- Copper could enhance defense reactions against soilborne pathogens.

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