Is Mitigation of Drought Stress By Zinc Oxide Nanoparticles Driven By a Nano-Specific Mechanism or Mitigation of Micronutrient Deficiency?

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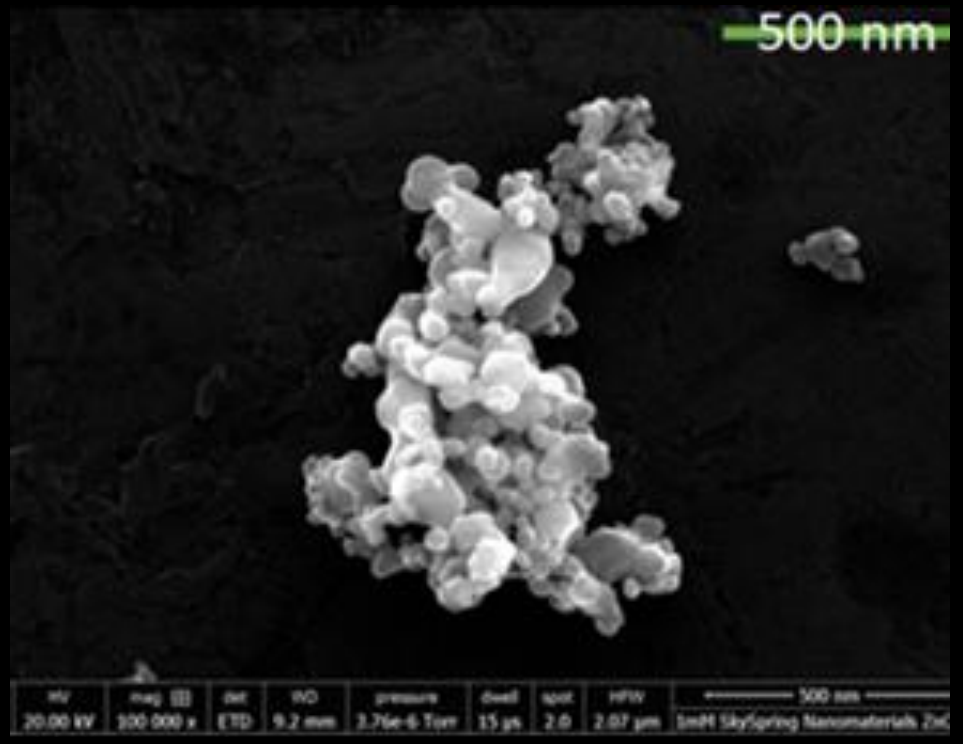
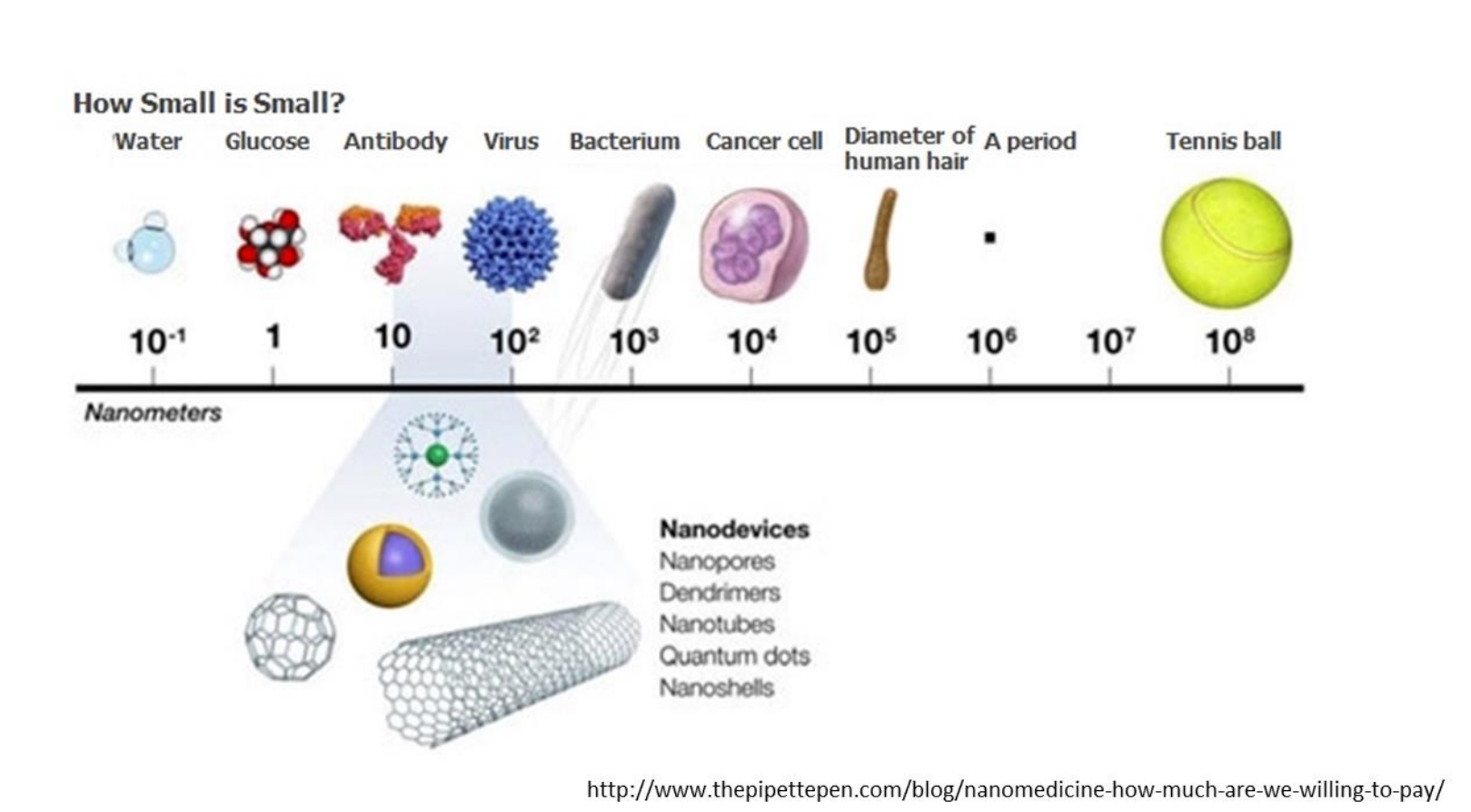
Background

- ZnO nanoparticles (NPs) are reported to improve plant drought tolerance.
- Many of the reported studies were conducted in Zn-deficient growth media.
- Zn deficiency has been shown to decrease drought tolerance.
- *Pseudomonas chlororaphis* isolate O6 (*Pc*O6) is a beneficial, root-colonizing microbe (Cho et al. 2008).



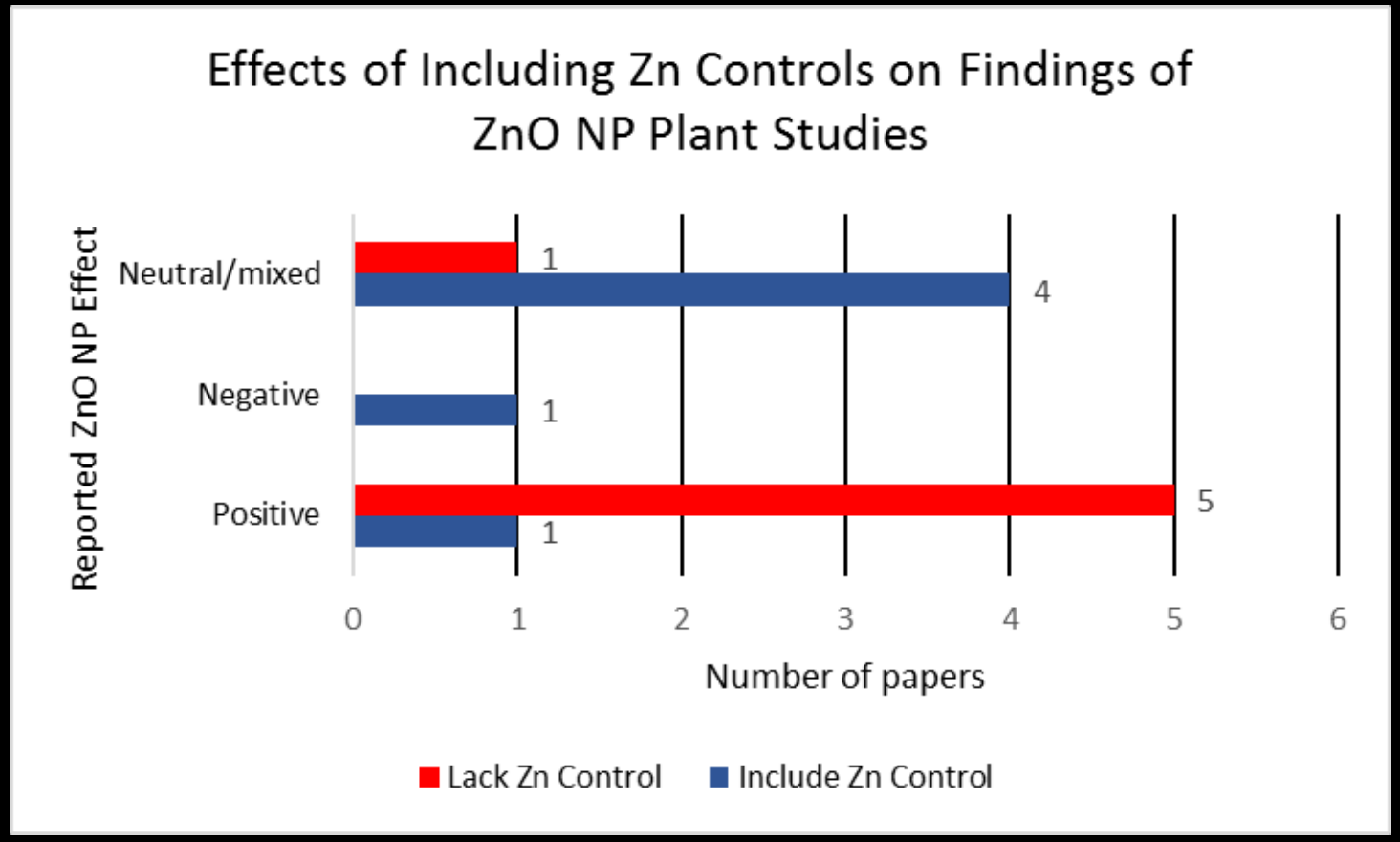
What is a Nanoparticle?

- Nanoparticles are less than 100 nm in any dimension.
- NPs affect crops differently than bulk fertilizers.



http://www.thepipettepen.com/blog/nanomedicine-how-much-are-we-willing-to-pay/

Literature Reviewed



Summary of the findings of 12 studies considering the effects of ZnO NPs on plant health, both in the presence and absence of drought.

Hypothesis

ZnO nanoparticle (NPs) amendment will not mitigate water stress in wheat (*Triticum aestivum*) grown in a nutrient-sufficient medium and inoculated with *Pseudomonas chlororaphis* isolate O6 (*Pc*O6).

- This would suggest that the benefits of ZnO NPs are simply caused by mitigation of a nutrient deficiency.

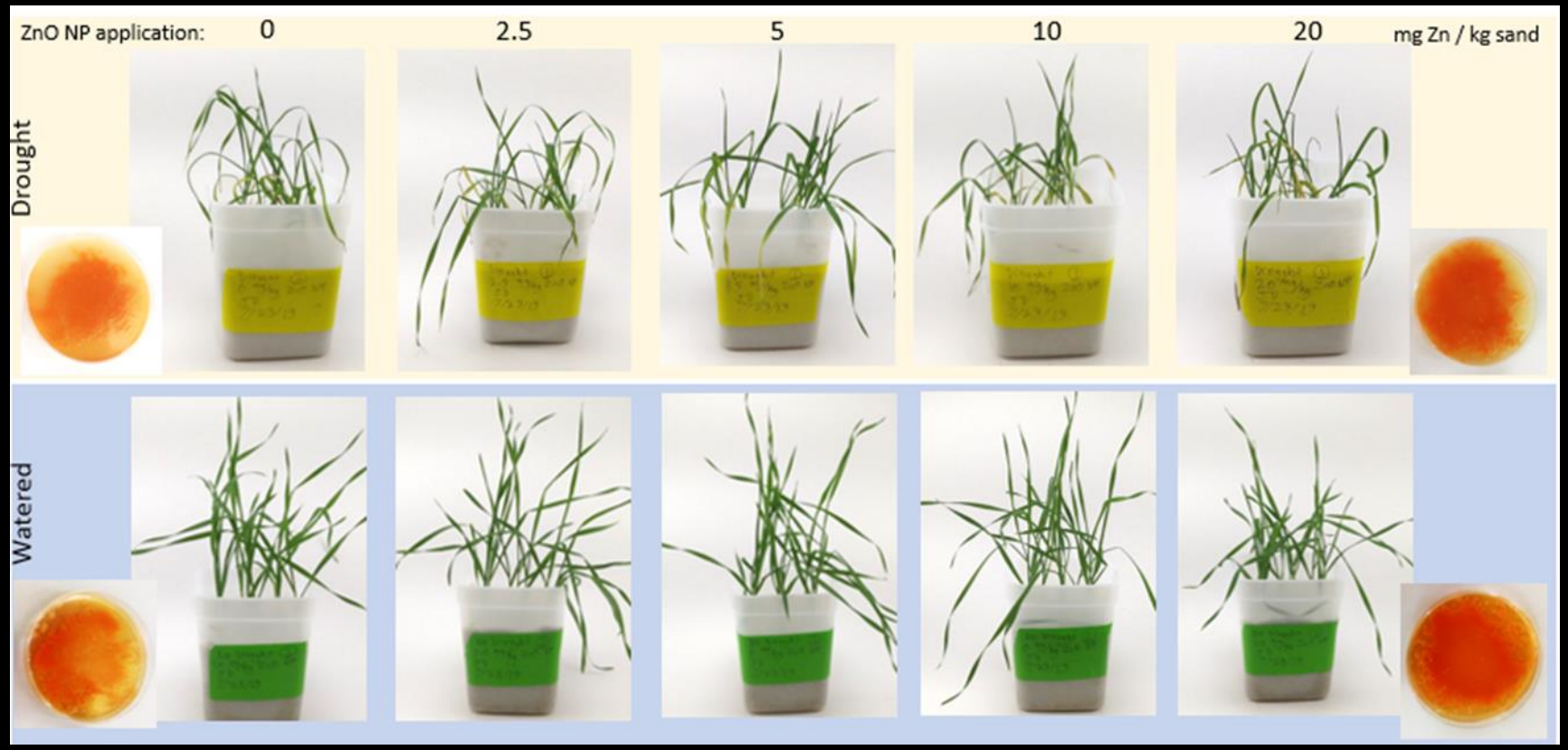
Methods

- Wheat seeds (v. Juniper) were inoculated with a probiotic, *Pseudomonas chlororaphis* isolate O6 (*Pc*O6).
- Inoculated seeds were planted in sand amended with ZnO NPs providing 0, 2.5, 5, 10, or 20 mg Zn/kg sand.
- Modified, half-strength Hoagland's solution was added at 0, 7, and 14 days to provide all essential plant nutrients, including Zn.
- Grown under white LED lights

Methods (continued)

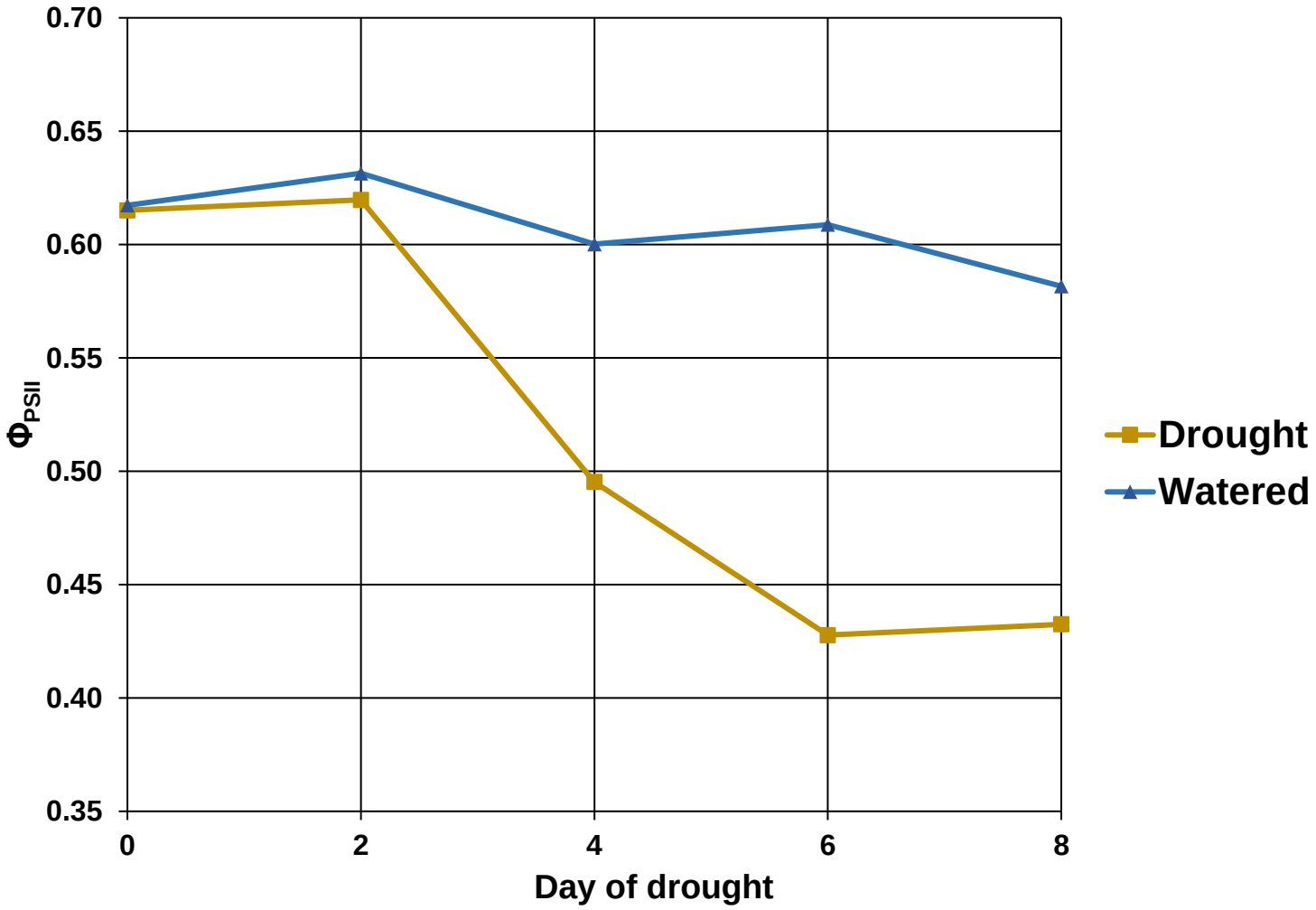
- Water restricted at day 14 for water-stressed plants.
  - Water-stress continued for 8 days
- Plants were watered daily to return to target water content:
  - Non-stressed water content: 0.169 g/g
  - Water-stressed water content: 0.025 g/g
- Drought stress was quantified by tissue dry mass and quantum yield of PSII (ΦPSII).
  - ΦPSII measurements made using a Licor 6800 Portable Photosynthesis System.

Preliminary Experiments



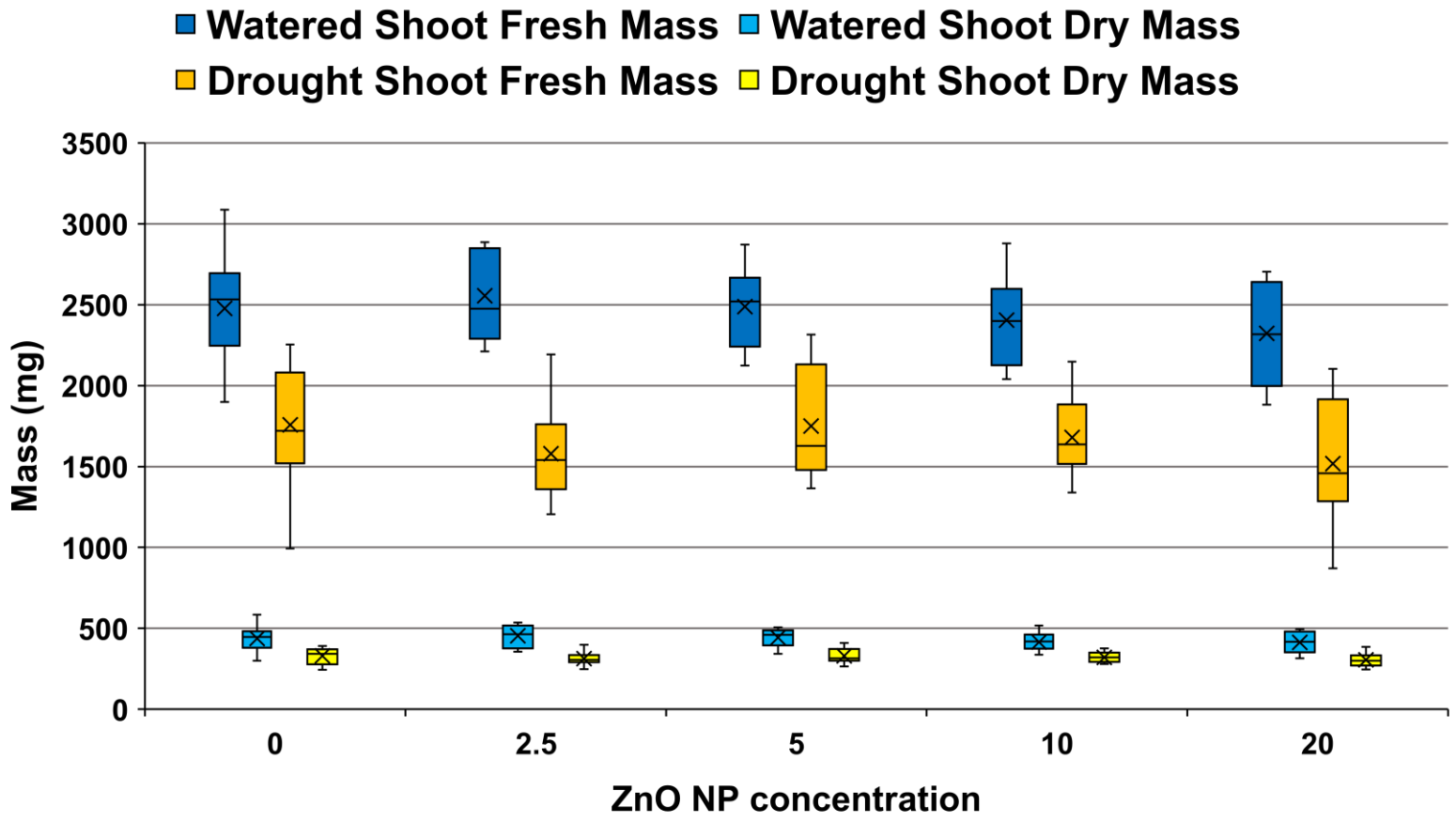
Wheat seedlings grown in a Zn-sufficient medium after 8 days of drought. Insets show Luria-Bertani media that was dabbed with roots.

Quantum Yield of PSII (ΦPSII)



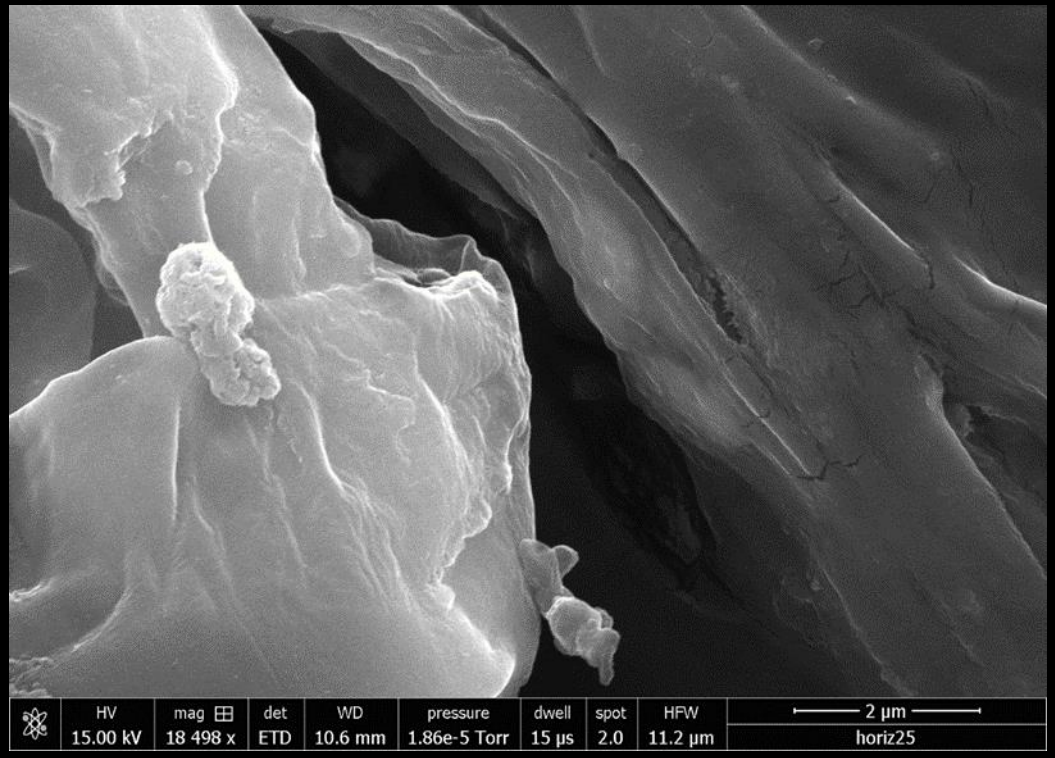
- Drought significantly reduced the quantum yield of PSII (ΦPSII).
- The addition of ZnO NPs as a sand amendment did not mitigate this reduction.

Shoot Mass



Drought reduced tissue production, but addition of ZnO NPs did not significantly mitigate reductions in leaf mass caused by drought.

Root Imaging



After 22 days of growth, no ZnO NPs could be located on the root surface.

Conclusions

- ZnO NPs did not mitigate drought symptoms in wheat seedlings grown in a growth matrix with sufficient nutrients.
- When evaluating the efficacy of ZnO NPs, experiments need to be designed in systems that represent currently available production techniques.
- Before adopting a new technology, crop advisors and growers need to ensure that the study applies to their growing conditions and includes a comparison with current management practices.

Acknowledgements

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