Evaluating the role of cerium oxide nanoparticles in the suppression of fusarium wilt disease in tomato (*Solanum lycopersicum*) plant

By

Ishaq O. Adisa

Environmental Science and Engineering, PhD Candidate

Dr. Jorge Gardea-Torresdey's Research Group

Chemistry Department, The University of Texas at El Paso

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Outline

- Background
- Objectives
- Experimental design
- Results
- Conclusion

Economic importance of tomato

- Tomato is the second most consumed vegetable in the US
- US is second only to China in tomato production in the world
- Generates over $2 billion annual revenue

Tomato fruits

http://venturesafrica.com/this-is-the-real-reason-why-you-are-paying-more-for-tomatoes-in-nigeria/

(USDA ERS., 2016)

Fusarium wilt in tomato

- Fusarium wilt is the most destructive pathogenic disease affecting tomato
- Reduces plant productivity and causes economic loss (USDA)

Plant infected by *fusarium oxysporum Source:*
http://pnwhandbooks.org/plantdisease/sites/default/files/images/TomatoFusariumWilt.jpg

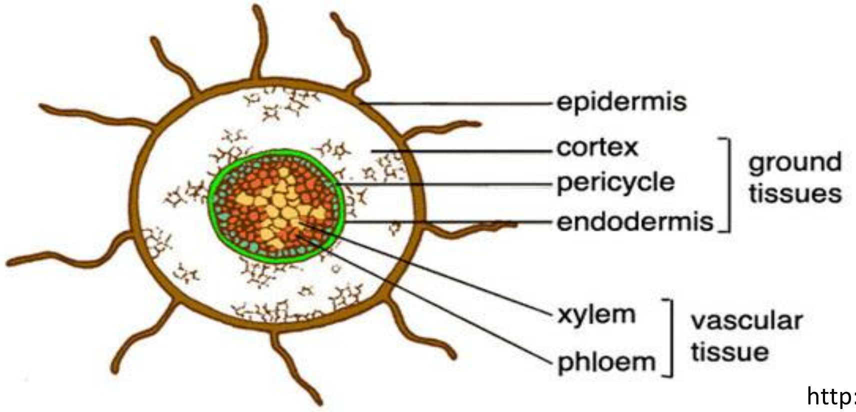


Figure 3. Cross section of a root

http://mrmitchellsbiology.weebly.com/uploads/1/0/4/2/10422385/857360245.jpg

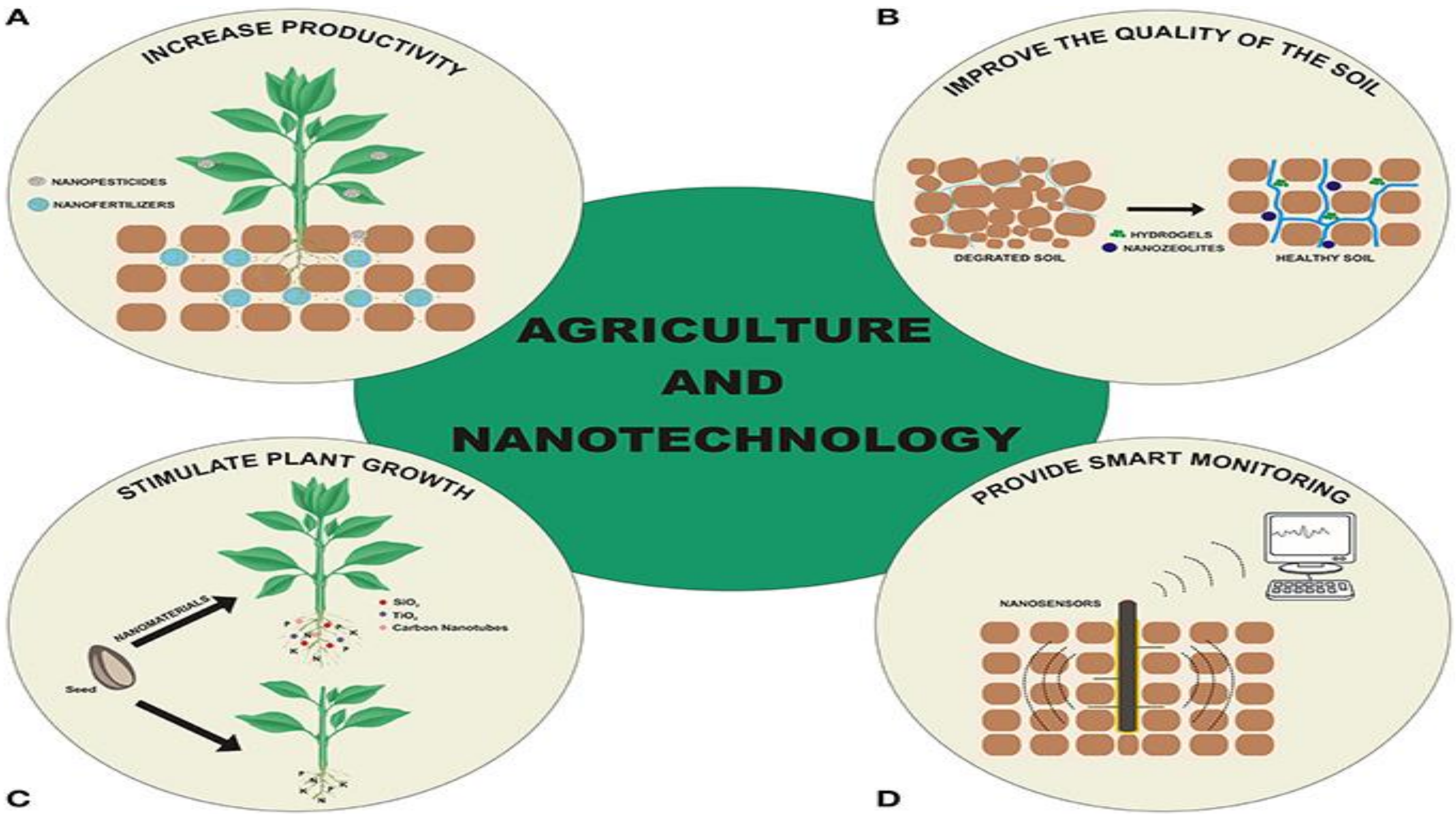
Conventional control of plant pathogenic diseases

- Genetic breeding
- Cultural schemes with sanitation
- Host indexing
- Enhanced eradication protocols
- New pesticide products
- Integrated pest management (IPM)

https://www.sciencedaily.com/images/2016/03/160331082500_1_900x600.jpg

(Servin et al., 2015)

Potential applications of nanotechnology in agriculture



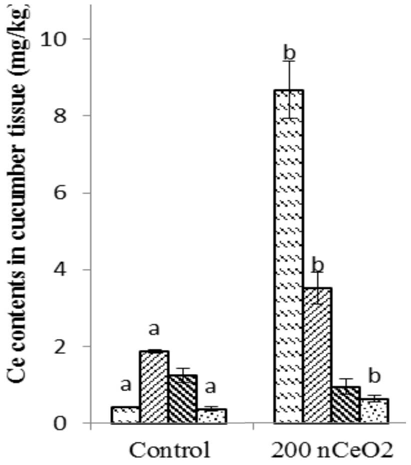
Fraceto *et al.*, (2016)

Positive impact of nanoparticles in plants

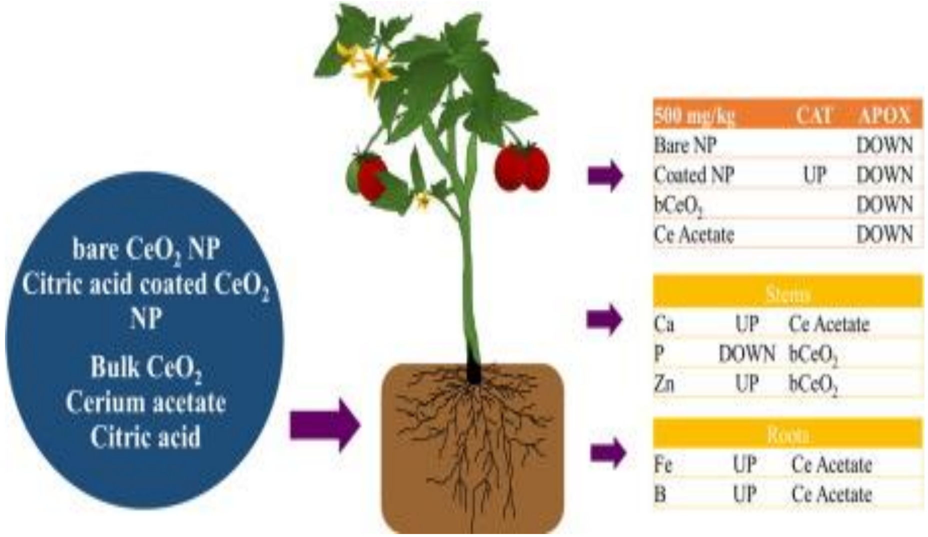
NPs	Size	Concentration	Application	Plant type	Effects	Reference
CeO_2	10-30 nm	100 mg/kg	Root	Soybean	Stimulates plant growth.	Cao *et al.* (2017)
ZnO	30±10 nm	0.1-0.5 mg/ml	Root	Tomato	Inhibit fusarium spore germination	Wani and Shah (2012)
CuO	30 nm	1 mg/l	Foliar	Eggplant	Verticillium wilt disease estimates, increase fresh weight	Elmer and White (2016)
MnO		0.5 ppm	Seed germination	Lettuce	Stimulates the plant growth	Liu *et al.,* (2016)
MnO	20 nm	0.05-1 mg/l	Root	Mung bean	Increase root and shoot length, fresh and dry biomass; enhance chlorophyll, carotene photophosphorylation and oxygen evolution	Pradhan *et al.* (2014)

Why CeO_2 nanoparticle

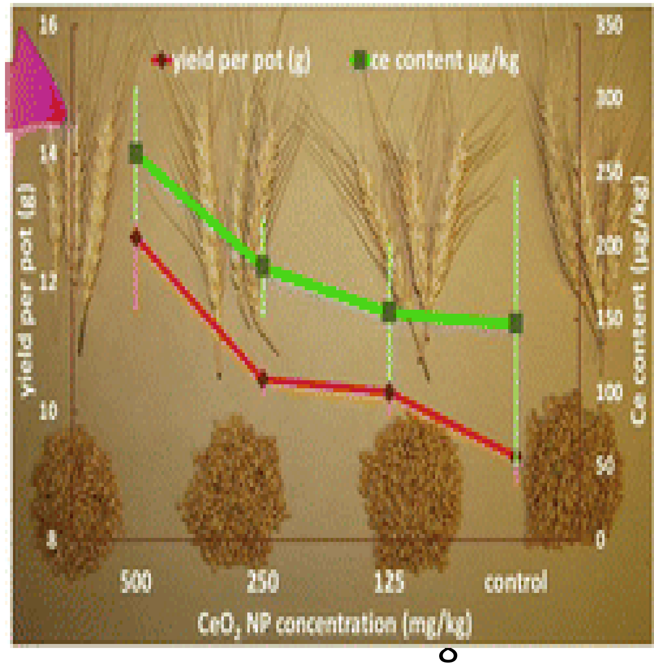
- Hong *et al.*, 2016



- Barrios *et al.*, 2016



- Rico *et al.*, 2014



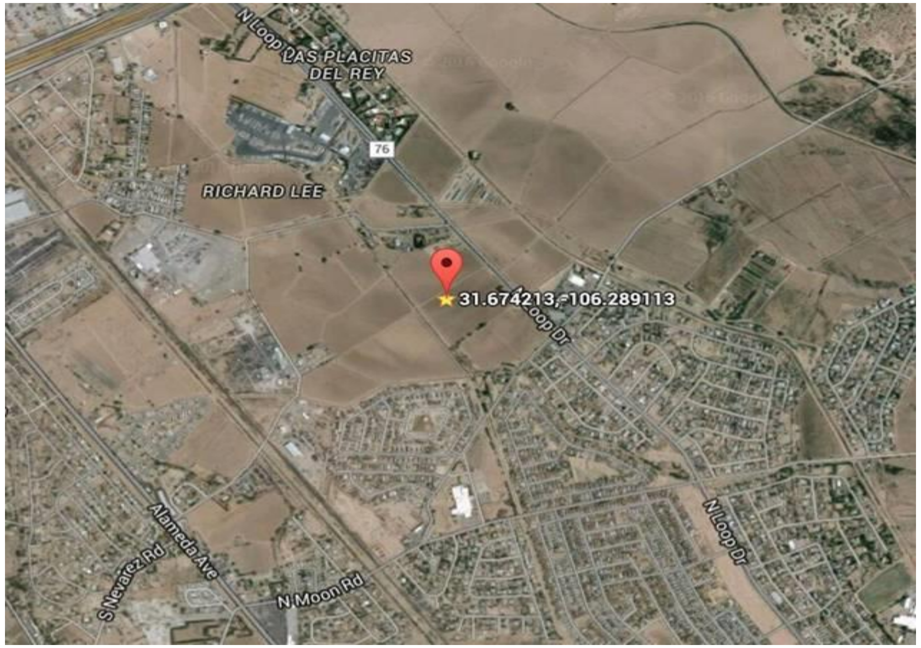
Objective

- To demonstrate the CeO_2 NP potential of inhibiting the fungal pathogen growth in tomato via root or foliar application

- To evaluate the impact of the nanoparticles on the nutritional value/yield of the tomato plant in suppressing the disease

Materials and methods

- **Bonny Best cv. organic seeds**
- ***Fusarium oxysporum lycopersicum* inoculum**
- **CeO_2 NP and ionic salt, cerium acetate (CeAc)**



Natural Soil Location

Experimental design

For CeO_2 NP or CeAc

	Control	Root Application		Foliar Application	
	0 mg/kg	50 mg/kg	250 mg/Kg	50 mg/l	250 mg/l
Infested	3	3	3	3	3
Non-infested	3	3	3	3	3

- **Triplicates were analyzed using one-way ANOVA and Tukey's HSD test ($p \leq 0.05$) SPSS 22**

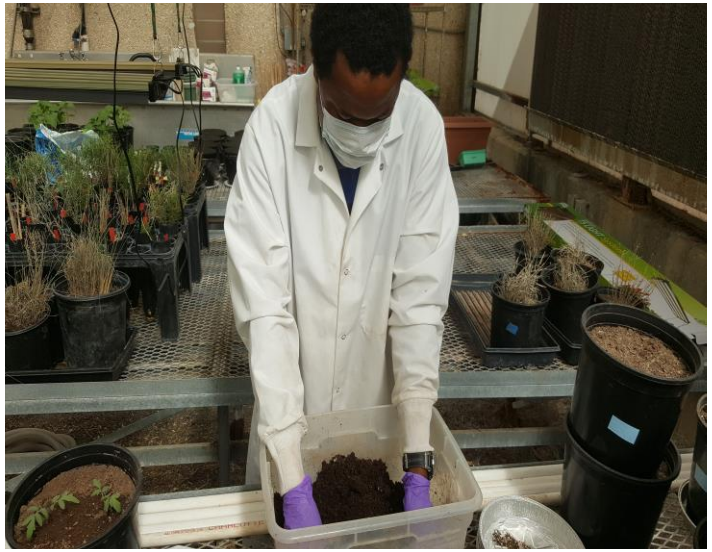
Plant growth

Seedlings grown in vermiculite

Root application

Foliar application

7 days after transplant



Inoculation with fusarium 7 days after transplant

Experimental analysis

- Disease Severity (using estimates of area under disease progress curve)
- Cerium accumulation (ICP-OES)
- Agronomical parameters
  - Shoot length
  - Total fruit weight
- Biochemical parameters
  - Chlorophyll content (SPAD)
  - Catalase activity (CAT) (UV-Vis)
  - Polyphenol oxidase activity (PPO) (UV-Vis)

Results

Soil applied

A **B** **C**

A = Control Infested

B = 250 mg/kg Soil-Root, Infested

C = 250 mg/kg Soil-Root, Non-Infested

Foliar applied

A **B** **C**

A = Control Infested

B = 250 mg/l foliar, Infested

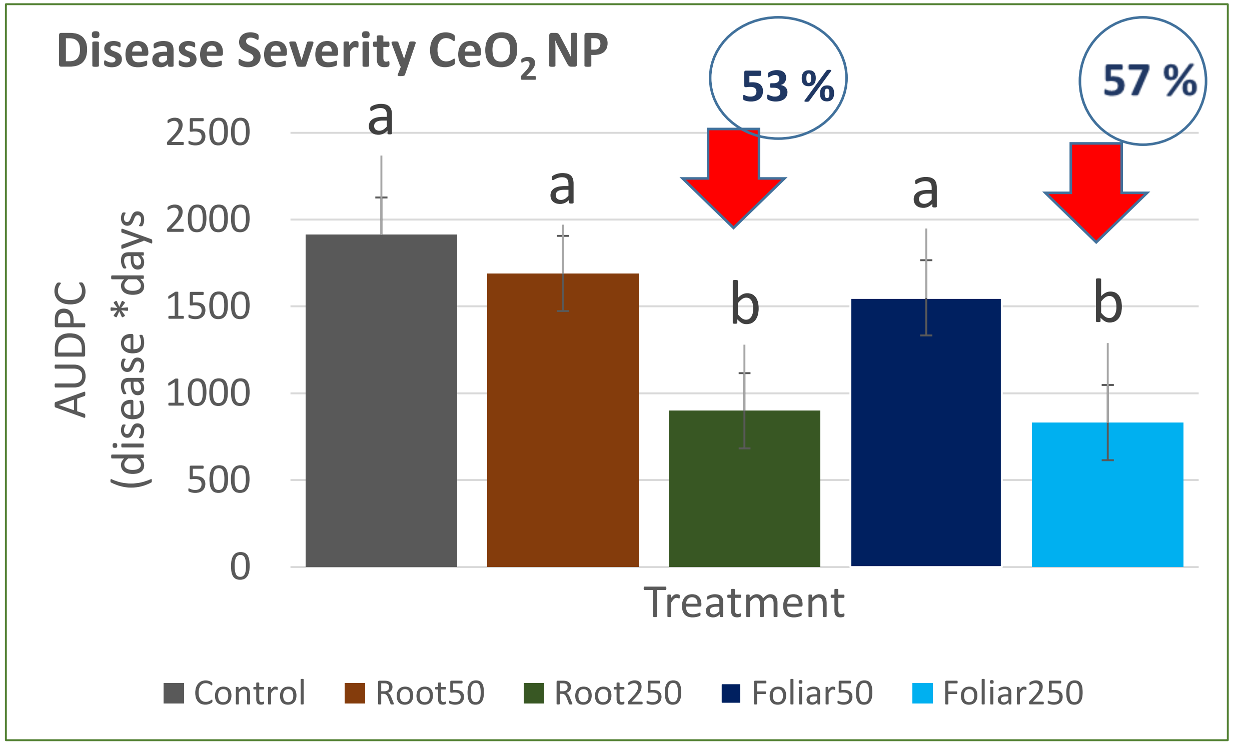
C = 250 mg/l foliar, Non-Infested

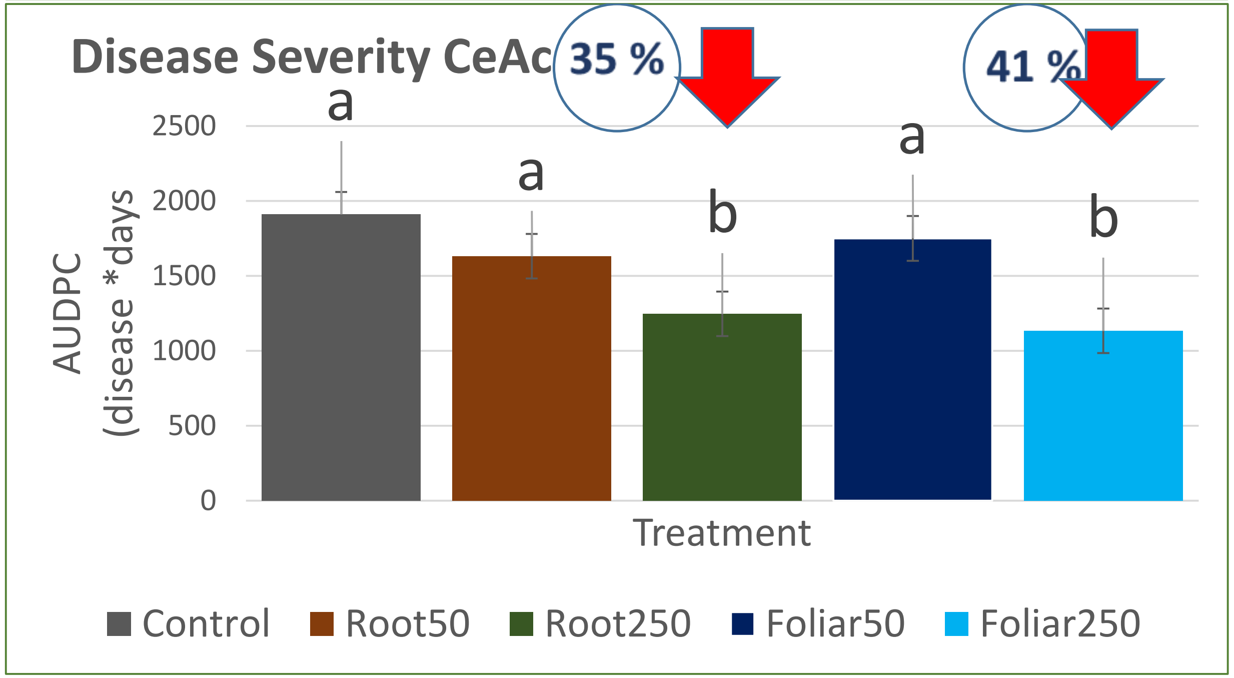
Results

Disease severity

- Root and foliar exposure of CeO_2 NP at 250 mg/l reduced the AUDPC

- Root and foliar applications CeAc at 250 mg/l , also reduced the AUDPC





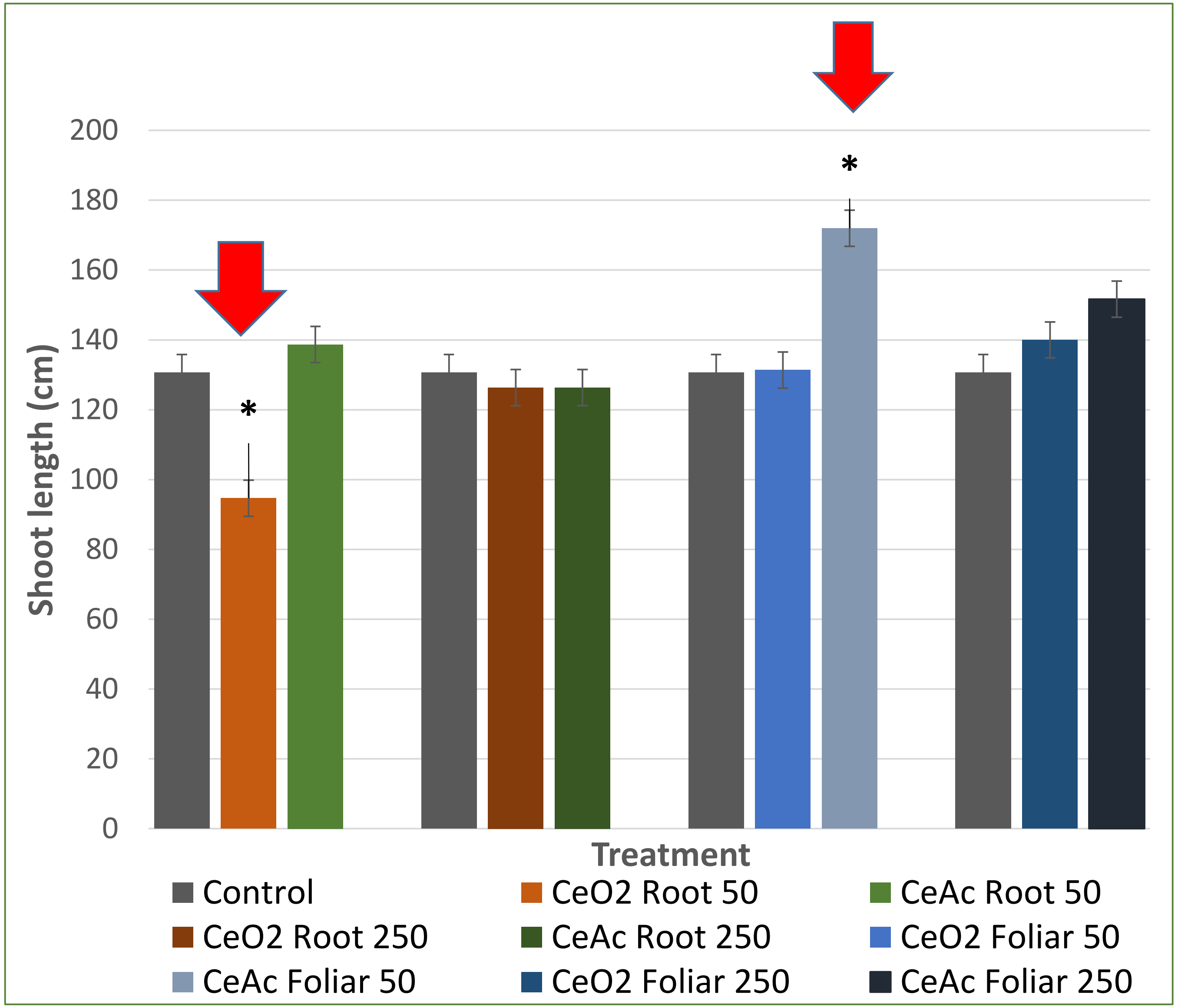
Cerium accumulation

		Root		Stem		Leaf	
Element	Treatment	Infested	Non-Infested	Infested	Non-Infested	Infested	Non-Infested
Ce (mg/kg)	Control	1.81±0.84	0.93±0.52	0.03±0.04	0.00±0.02	0.38±0.09	0.001±0.04
	Root CeO_2 50	5.77±0.84	3.41±0.52	0.00±0.04	0.02±0.02	0.37±0.09	0.24±0.04*
	Root CeAc 50	1.08±0.84	0.82±0.52	0.06±0.04	0.03±0.02	0.29±0.09	0.23±0.04*
	Root CeO_2 250	3.15±0.84	3.88±0.52*	0.05±0.04	0.01±0.02	0.37±0.09	0.32±0.04*
	Root CeAc 250	3.92±0.84	10.77±0.52*	0.06±0.04	0.01±0.02	0.27±0.09	0.13±0.04
	Foliar CeO_2 50	2.18±0.84	0.62±0.52	0.05±0.04	0.01±0.02	0.13±0.09	0.14±0.04
	Foliar CeAc 50	0.87±0.84	3.06±0.52	0.00±0.04	6.94E-18±0.02	0.02±0.09	0.19±0.04
	Foliar CeO_2 250	0.6±0.84	1.45±0.52	0.05±0.04	0.11±0.02a	0.29±0.09	0.002±0.04
	Foliar CeAc 250	1.41±0.84	1.53±0.52	0.00±0.04	6.94E-18±0.02	0.17±0.09	0.04±0.04

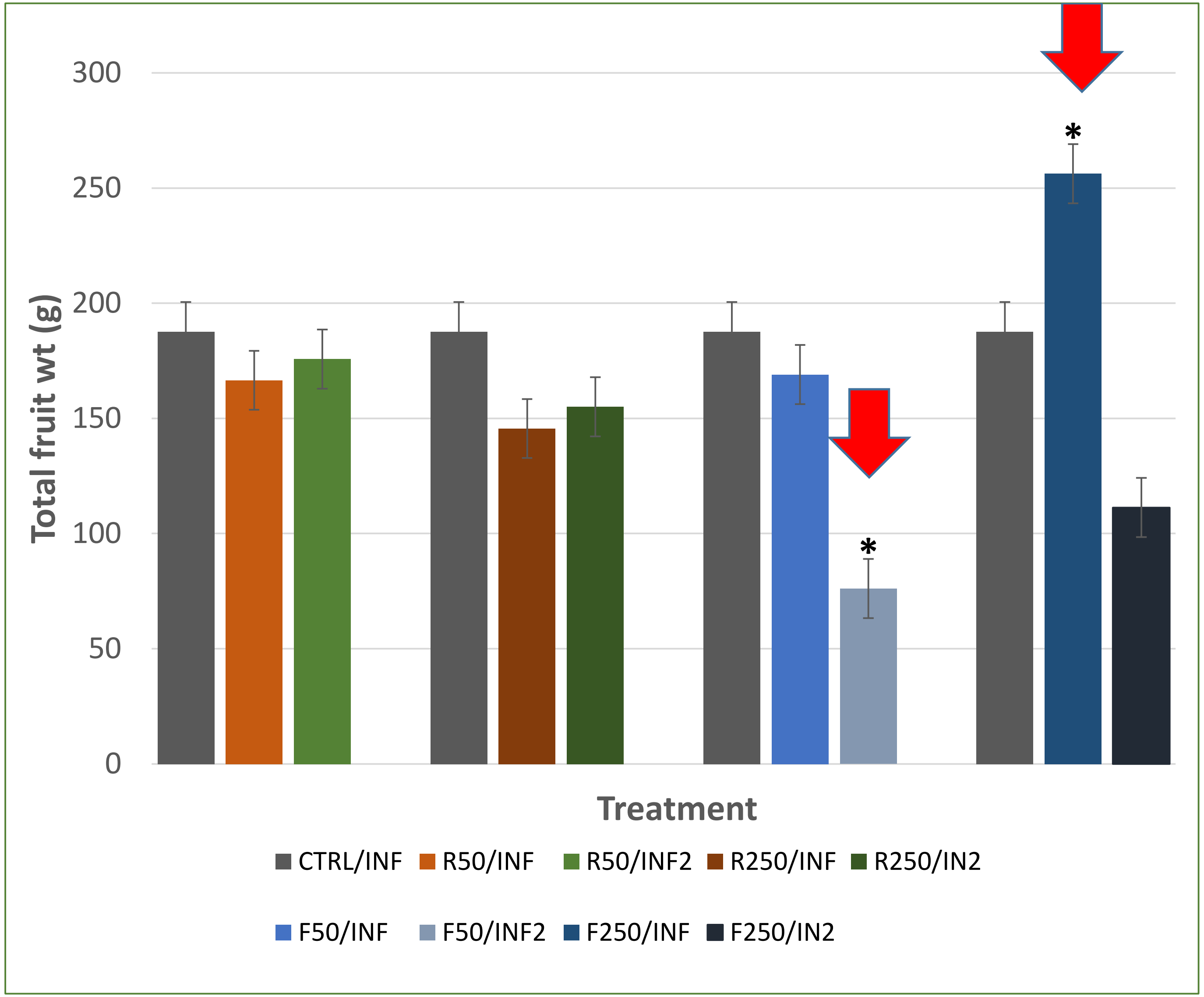
Effect of Cerium compounds on shoot length of infested tomato

- Root exposure to 50 mg/kg of CeO_2 NP reduces shoot length by 28 %

- Foliar exposure to CeAc at 50 mg/l increases by 32 %



Effect of Cerium compounds on total fruit wt of infested tomato plant

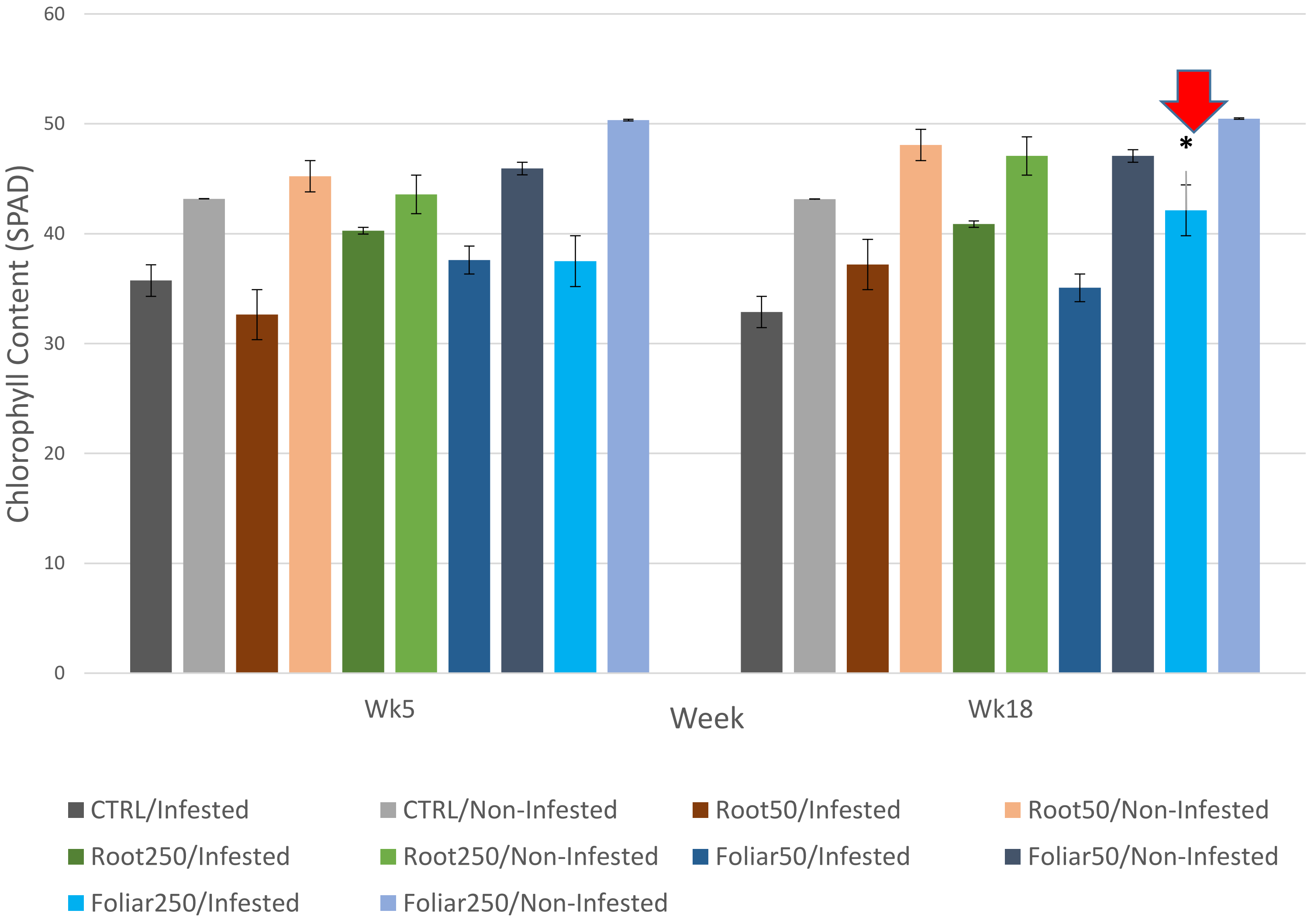


- **Foliar exposure to 250 mg/l CeO_2 NP, increases total fruit weight by 37 %**

- **CeAc at 250 mg/l reduced by 59 %**

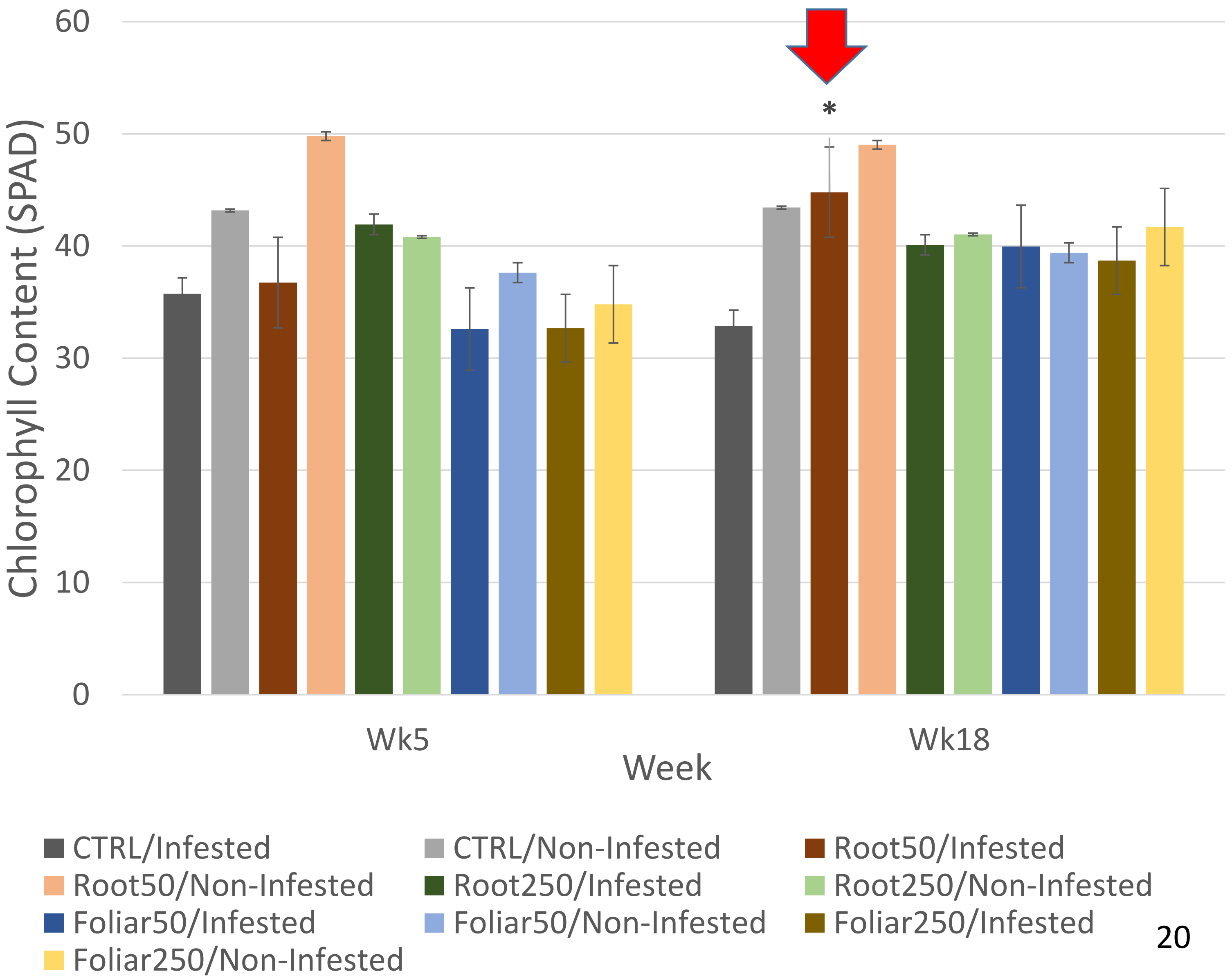
Effect of CeO_2 NP on chlorophyll content

- CeO_2 NP at 250 mg/l foliar exposure (infested) increases the chlorophyll content by 28 %



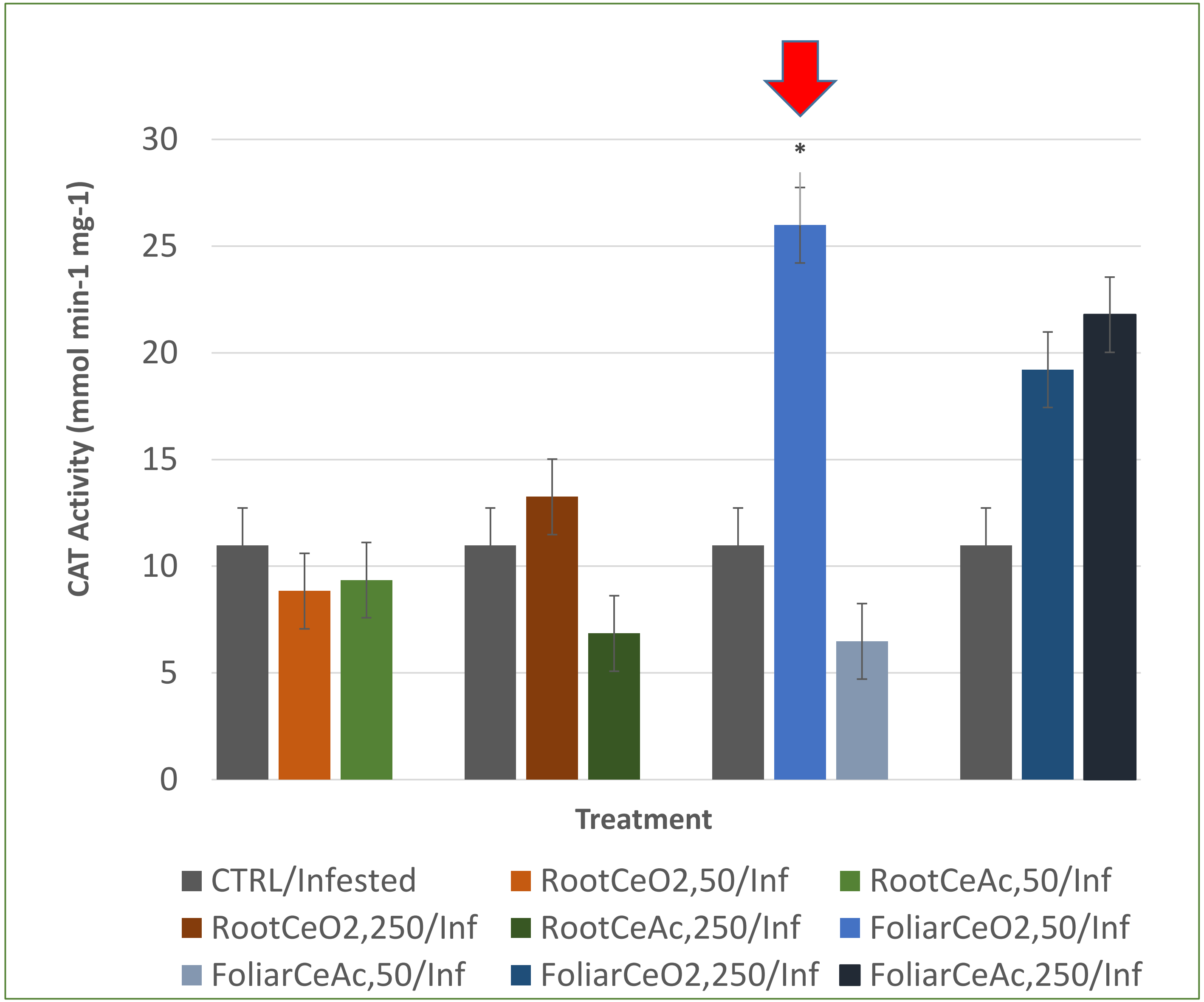
Effect of CeAc on chlorophyll content

- At harvest, 50 mg/l CeAc exposure increased the chlorophyll content by 49 %



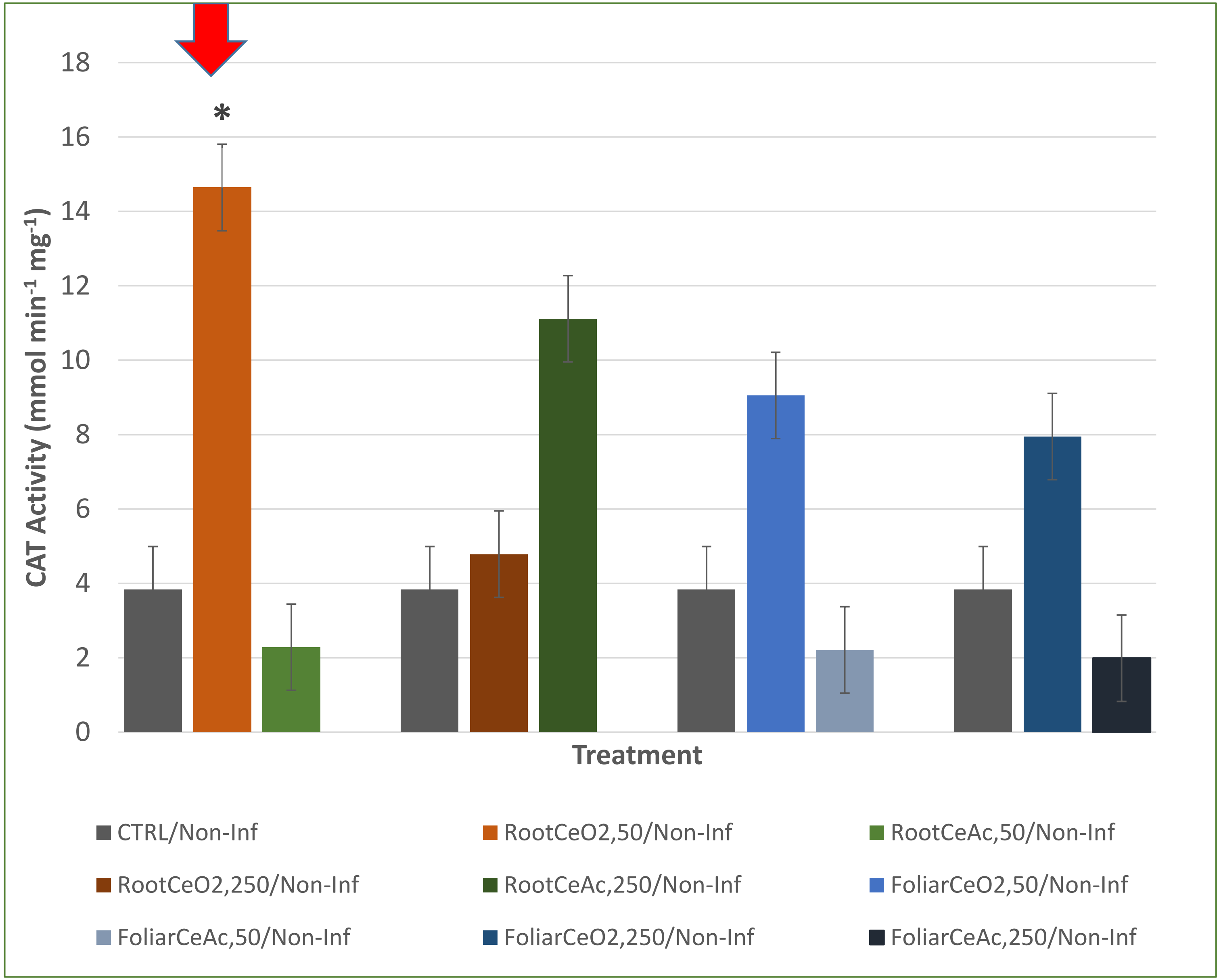
Catalase activity in the roots of infested tomato

- Foliage exposure to 50 mg/l of CeO_2 NP, increased the CAT by 137 %



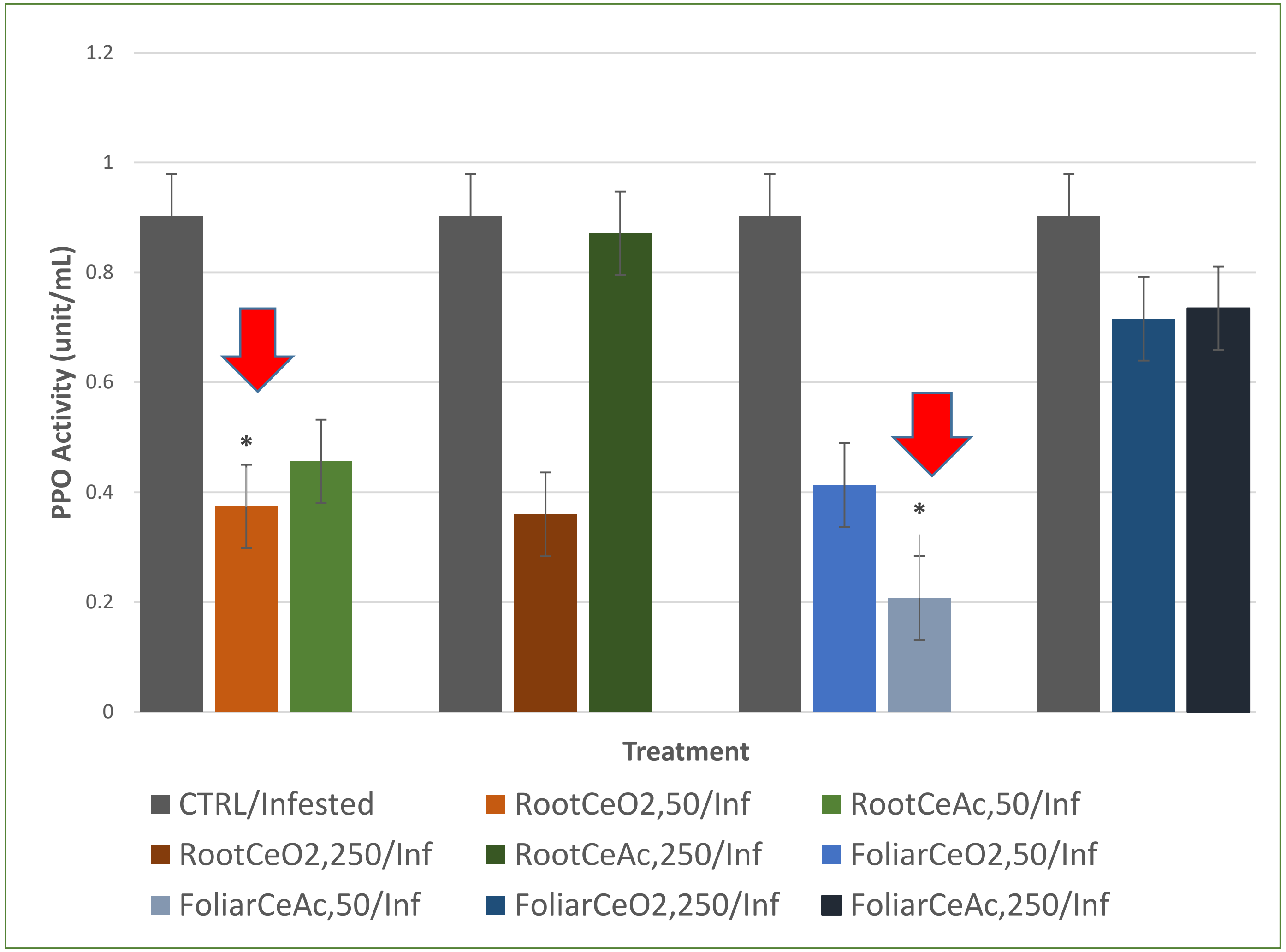
Catalase activity in the roots of non-infested tomato

- **Root exposure to 50 mg/kg CeO_2 NP increased the CAT by 283 %**



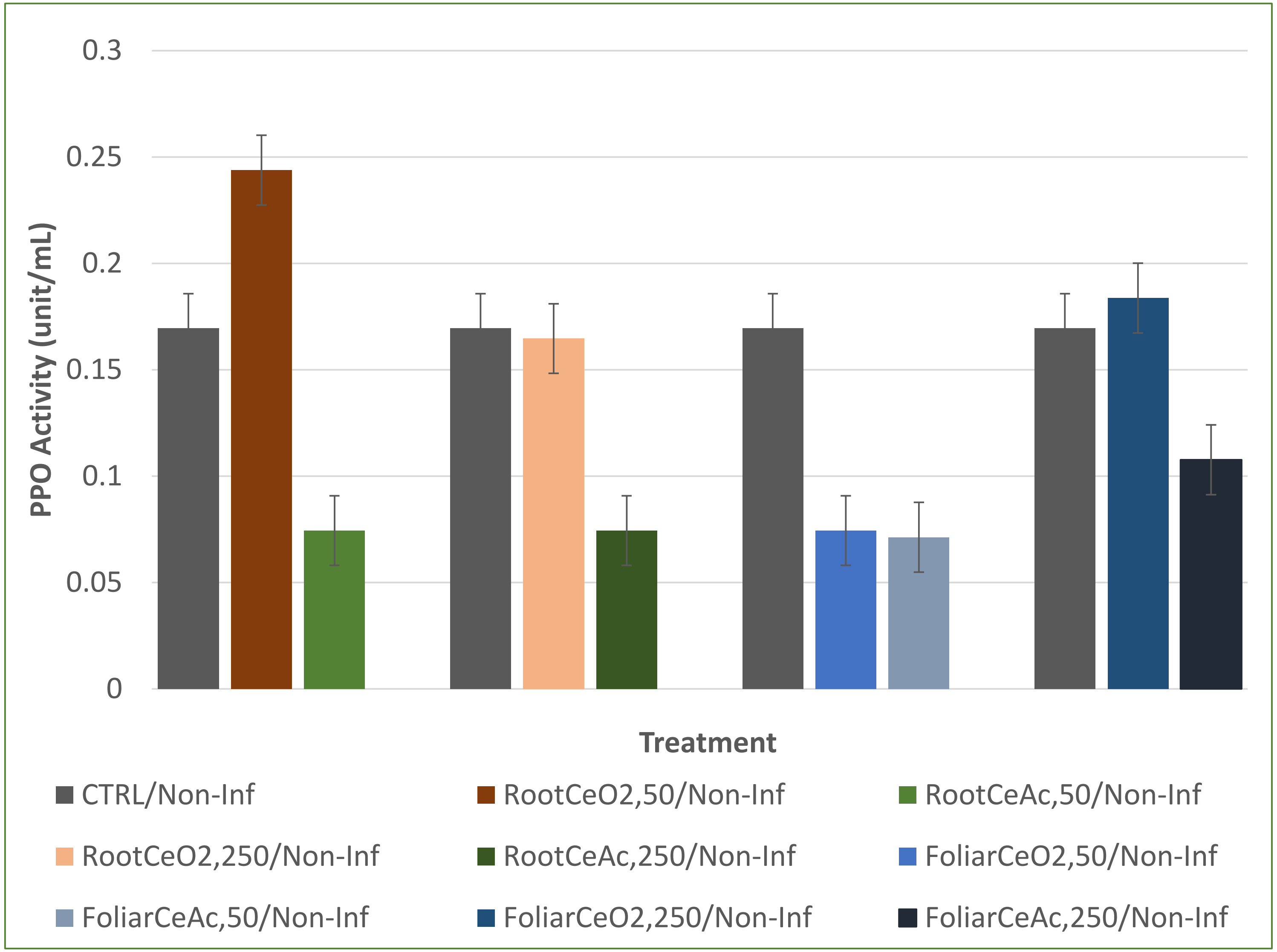
Polyphenol oxidase activity in root of infested tomato

- **Root and foliar exposure to 50 mg/l CeO_2 NP decreased the PPO activity by 53% and 57%, respectively**



Polyphenol oxidase activity in the roots of non-infested tomato

- No significant difference in PPO activities



Conclusion

- The results from this study suggests that root and foliar applications of CeO_2 NP at 250 mg/L has potential to suppress fusarium wilt disease in tomato
- CeO_2 NP has potential to increase the productivity of tomato plant
- CeO_2 NP impacts the stress enzyme (CAT) and defense enzyme (PPO) at 50 mg/L concentration
- No Ce accumulation across the tissues of infested plants; suggests no toxicity result from the tested concentrations
- Further biochemical studies need to be conducted to fully understand the mechanism

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Questions