Plant-based Carbon Nanoparticle (PCNP) Application on Lettuce to Improve Nitrogen (N) Recovery

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Background

- AG Order 4.0 places limits on the amount of nitrogen (N) application on over 100 million acres of irrigated farmland in the Salinas Valleys "Salad Bowl".
- Lettuce (*lactuca sativa*) production in the Salinas Valley requires applying large amounts of N fertilizer.
- Agricultural runoff in the region contains unsafe rates of nitrate contamination that compromise the groundwater drinking supply and causes eutrophication in the Monterey Bay.
- In the Salinas Valley, cropland is responsible for approximately 90% of the groundwaters nitrate (NO_3) contamination
- Plant based carbon nanoparticles (PCNPs) have the capacity to increase plant N uptake, reducing runoff and leaching. PCNPs can also be mixed with fertilizers to make nanofertilizers.

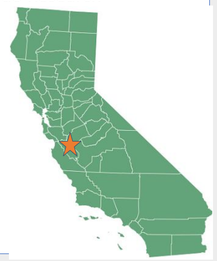
Objective

- Investigate the impact of PCNP applications on romaine lettuce leaf yields and N recovery as well as NO_3 leaching using typical Salinas Valley agricultural soils.

Materials and Methods

Study Site

- Site: Greenhouse at the Vilmorin-Mikado Research Farm in Salinas, CA
- Soil type
  Chular: Sandy loam soil
  - 81% sand, 7.5% clay, 11.5% silt
  - 1% Organic Matter
  - CEC: 6.8 meq/100 g, pH: 6.9
  - NO3-N = 12ppm (low)
  - P = 21ppm (low)
  - K = 112 ppm (medium)



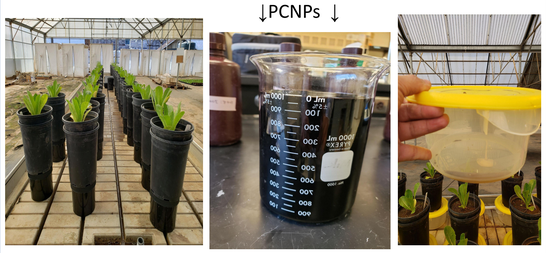
Experimental Design and Setup

Completely Randomized Design

- 8 treatments with 4 replications per treatment - 32 pots total.
- Plants started in flats and transplanted to 1-gal pots after ~ 4 weeks
- Soil added to pots was first sieved. A mesh screen and a thin layer of gravel was added for filtration and retaining soil.

- Drainage holes were drilled into pots to allow the flow of leachate into collection basins.
- Hoagland (N free) solution was applied at fertilization events to provide all other essential nutrients.
- 25% N added one week after transplanting. 75% N added 24 days after transplanting.

↓PCNPs ↓



Data Collection Activities

SPAD and Leachate data collection

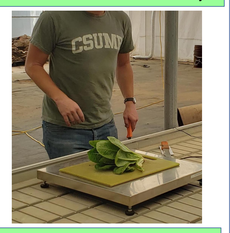
- Handheld SPAD meters measured lettuce N uptake weekly after the second week following transplant.
- As SPAD values increase, chlorophyll and N. concentrations increase.
- Provides unitless numerical value (0-60) proportional to a leaf's chlorophyll content.

Leachate Collection

- Leachate catchment basins were gathered then filtered on a weekly basis for nitrate testing.

Nitrogen Recovery by Lettuce at End of Study

- Following harvest, the aboveground biomass was weighed for fresh weight yields, oven-dried, then ground to pass a 1-mm sieve, and analyzed for N concentration in a commercial lab.



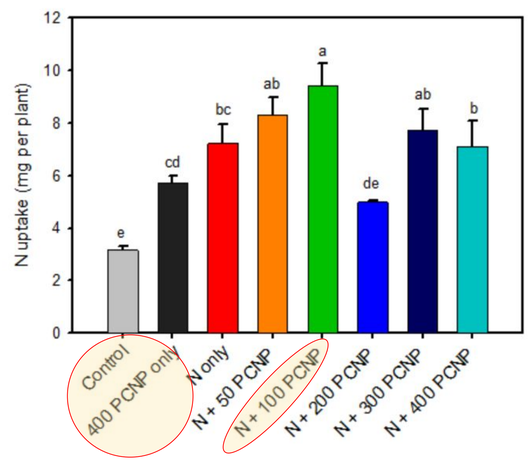
Soil Inorganic Nitrogen at the End of Study

- Following harvest, soil cores were taken from pots to determine NO_3-N concentrations
- Treatments did not affect soil nitrate concentrations.

Concentrations were low at end of study, at 2-3 parts per million.

Results

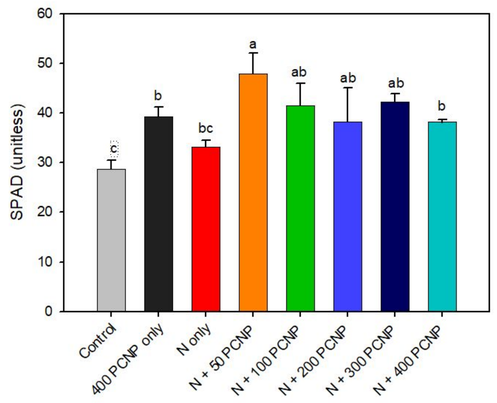
Nitrogen Uptake by Lettuce



- The control and 400 ppm PCNP treatments above did not receive N fertilizer.
- The graph's data implies applying PCNPs may have improved N uptake. N uptake peaked with N + 100 PCNP.
- Moderate applications of PCNPs appear to be effective in the Chular sandy loam agricultural soil.

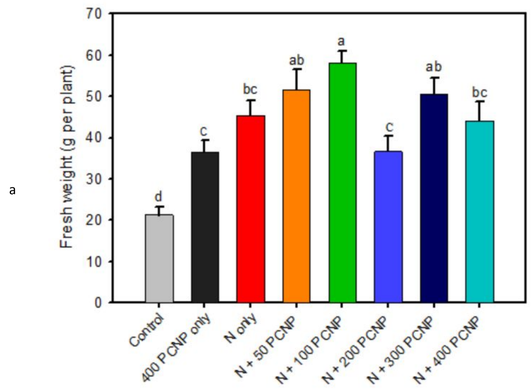
Lettuce N Accumulation and Yield Performance by Carbon Based Nanoparticles

Soil Plant Analysis Development (SPAD)



- The highest SPAD readings resulted from a moderate, 100 ppm plant based CNP treatment + N hoagland fertilizer.

Fresh Weight Yield Data



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- The heaviest fresh weight yields also resulted from the 100 ppm plant based CNP treatment + N fertilizer.

Conclusions

- Applications of plant-based carbon nanoparticles in conjunction with fertilizer improved N recovery and lettuce yields on a sandy loam soil from the Salinas Valley.
- Repeat trails to analyze effects on NO_3-N leaching on the sandy loam Chuar and other agricultural soils is underway.

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