Utilization of manure feedstock biochars as P fertilizer for cotton

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Agricultural Research Service, USDA

Agricultural Research Service

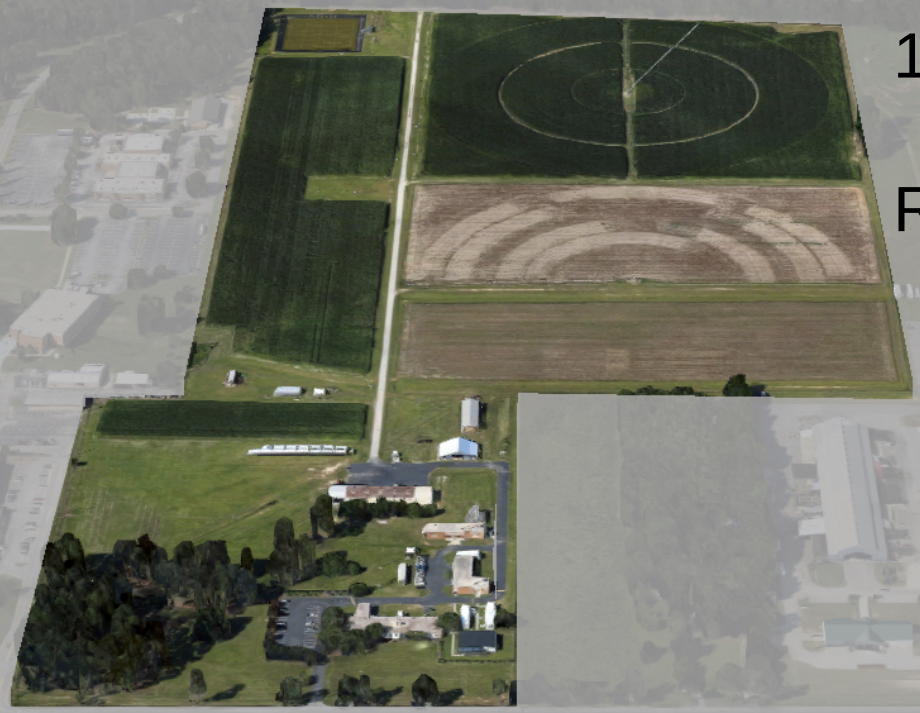
- USDA's chief scientific in-house research agency
- Over 2000 scientists and post-doctoral researchers
- 90+ research locations (in US and abroad)

Vision

… to lead America towards a better future through agricultural research and information.

Coastal Plains Soil, Water, and Plant Research Center

Florence, SC



10 research scientists

Research focus:

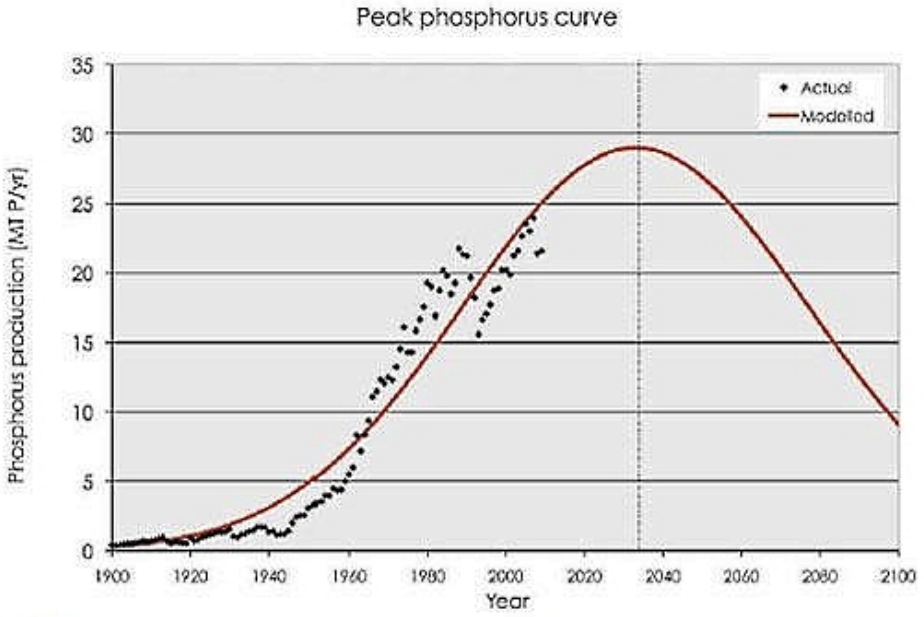
- Cotton Genetics
- Manure
- Soil
- Water

Biochar

- myriad uses (industrial, municipal, agricultural)
- agricultural
  - emission reduction/adsorption
  - soil amendment
    - conditioning/reclamation, increase soil fertility
    - increase water retention, reduce N leaching
    - fertilization
      - nutrients (N, **P**, K, etc)

Biochar as Phosphorus Fertilizer?

- Limited nutrient
  - peak production (predicted 2033)
  - declining supply / increased prices
  - subject to geopolitical influences
    - major supplies are in Morocco, China, Western Sahara
    - reserves in Iraq, Algeria, Syria



Biochar as Phosphorus Fertilizer?

- Raw manure
  - not nutrient dense
    - limited transportation
  - excess nutrients
    - particularly N and P
    - also Cu and Zn
  - active vs passive treatment
    - economics and the political/regulatory landscape
  - limited land application
    - based on nutrient loads
  - pathogens, antibiotic resistance (ARB/ARG)

Experimental Setup

- pot study (6.1 kg)
- *Gossypium hirsutum*
- 5 biochar feedstocks
  - chicken litter
  - turkey litter
  - beef manure
  - dairy manure
  - swine manure
- Produced at two temperature's
  - 350 °C and 700 °C

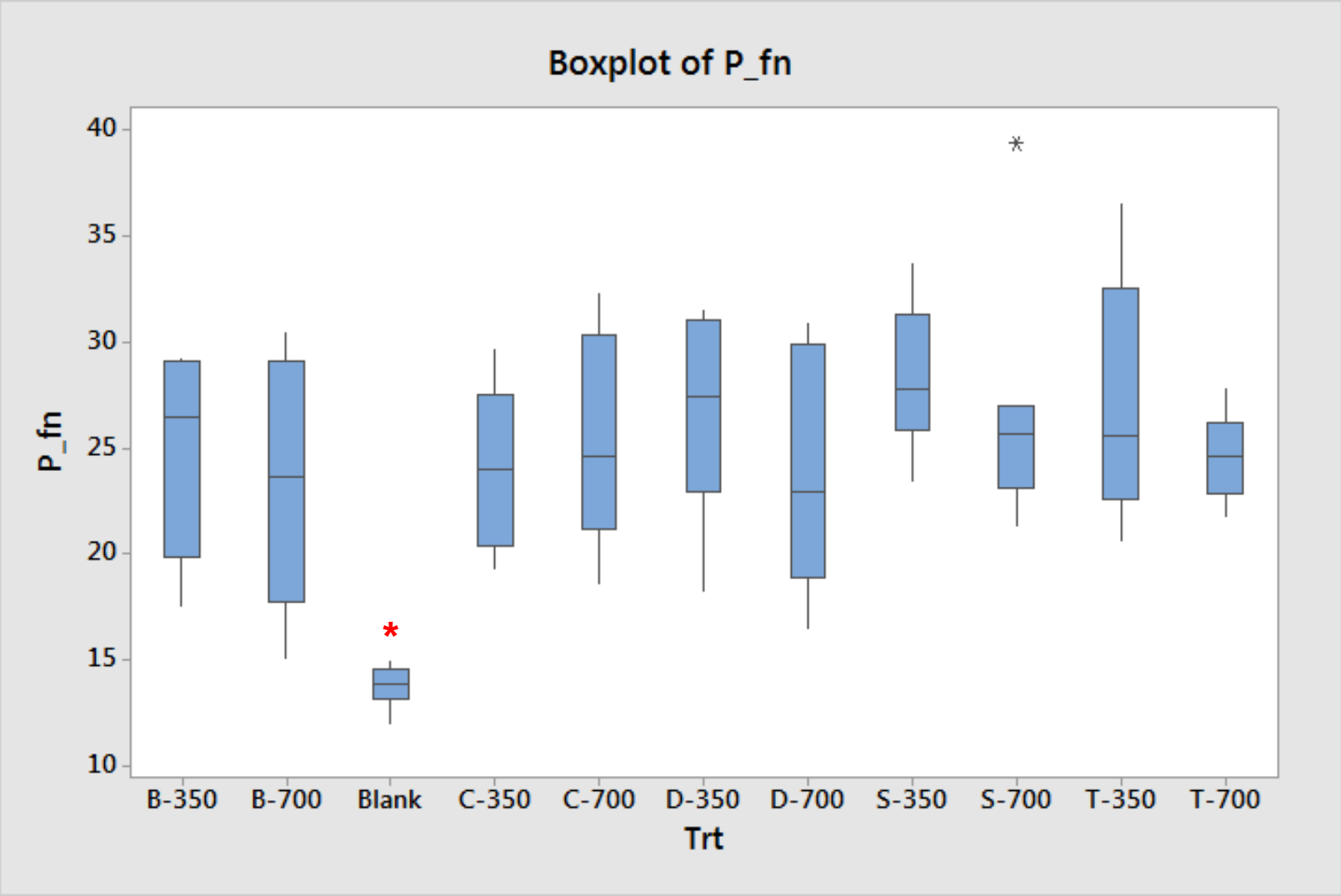
Experimental Setup (con't)

- biochar amendment based on P content
  - rate equivalent of 40 mg/kg P_2O_5
- N added at 50 mg N per kg soil (NH_4Cl)
- control treatment = unamended soil
  - low P forest soil (Norfolk loamy sand)
- limed to pH 6.0 prior to biochar addition
- irrigated twice daily (0.25" water/pot/day)
- plants harvested on day 60
  - leaf and stem samples collected

Phosphorus Amendment

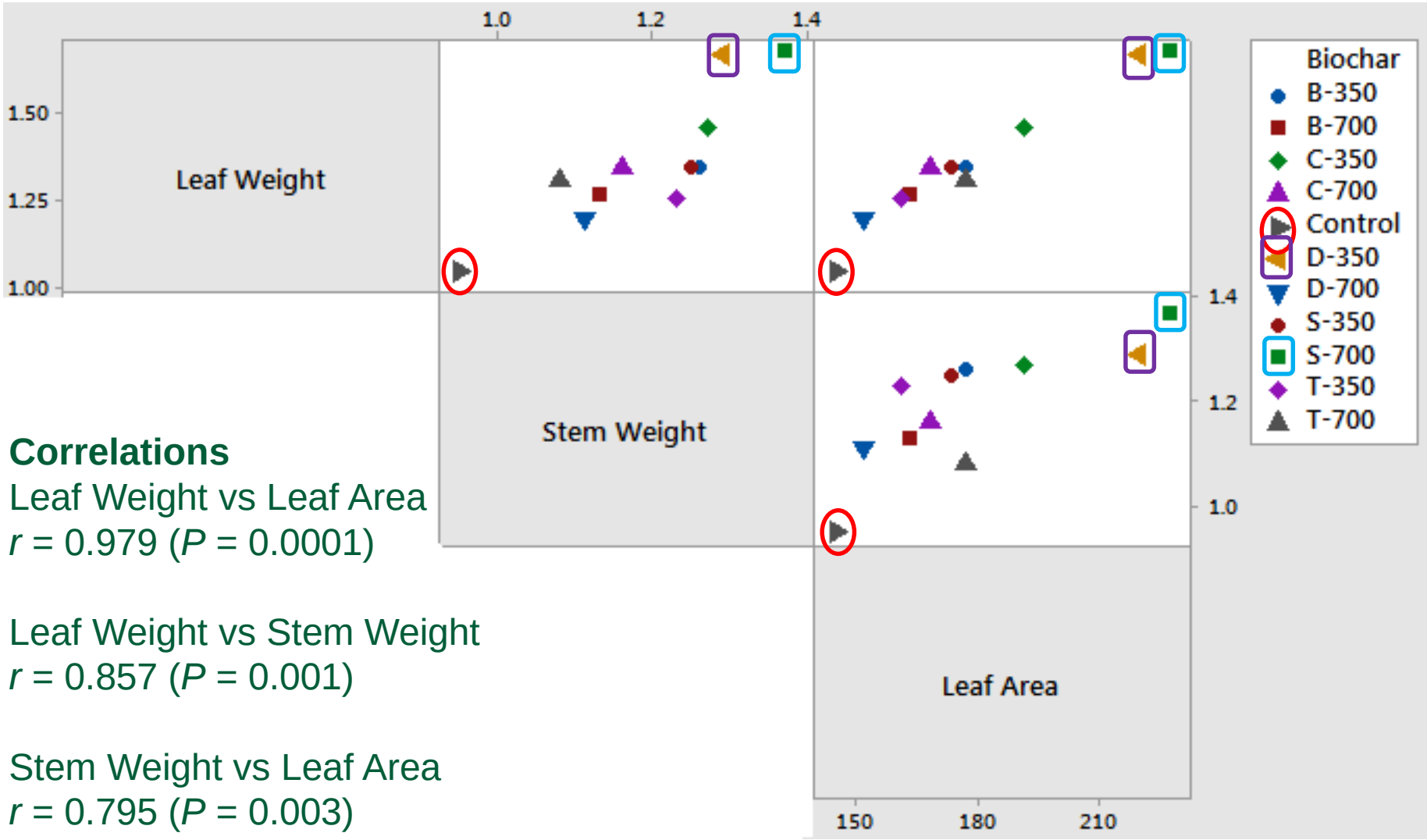
Treatments	Desired application rate P_2O_5 (mg /kg)	Biochar application rate (g char/pot)	Biochar amendment rate (%)
D-350	40	10.59	0.20%
D-700	40	6.31	0.10%
B-350	40	9.35	0.15%
B-700	40	6.06	0.10%
C-350	40	5.13	0.09%
C-700	40	3.41	0.06%
S-350	40	2.74	0.05%
S-700	40	1.81	0.03%
T-350	40	4.07	0.07%
T-700	40	2.91	0.05%

Soil Phosphorus



Phosphorus 40 mg/kg rate final extractable soil P level = 23.7 mg/kg

Plant Growth Results



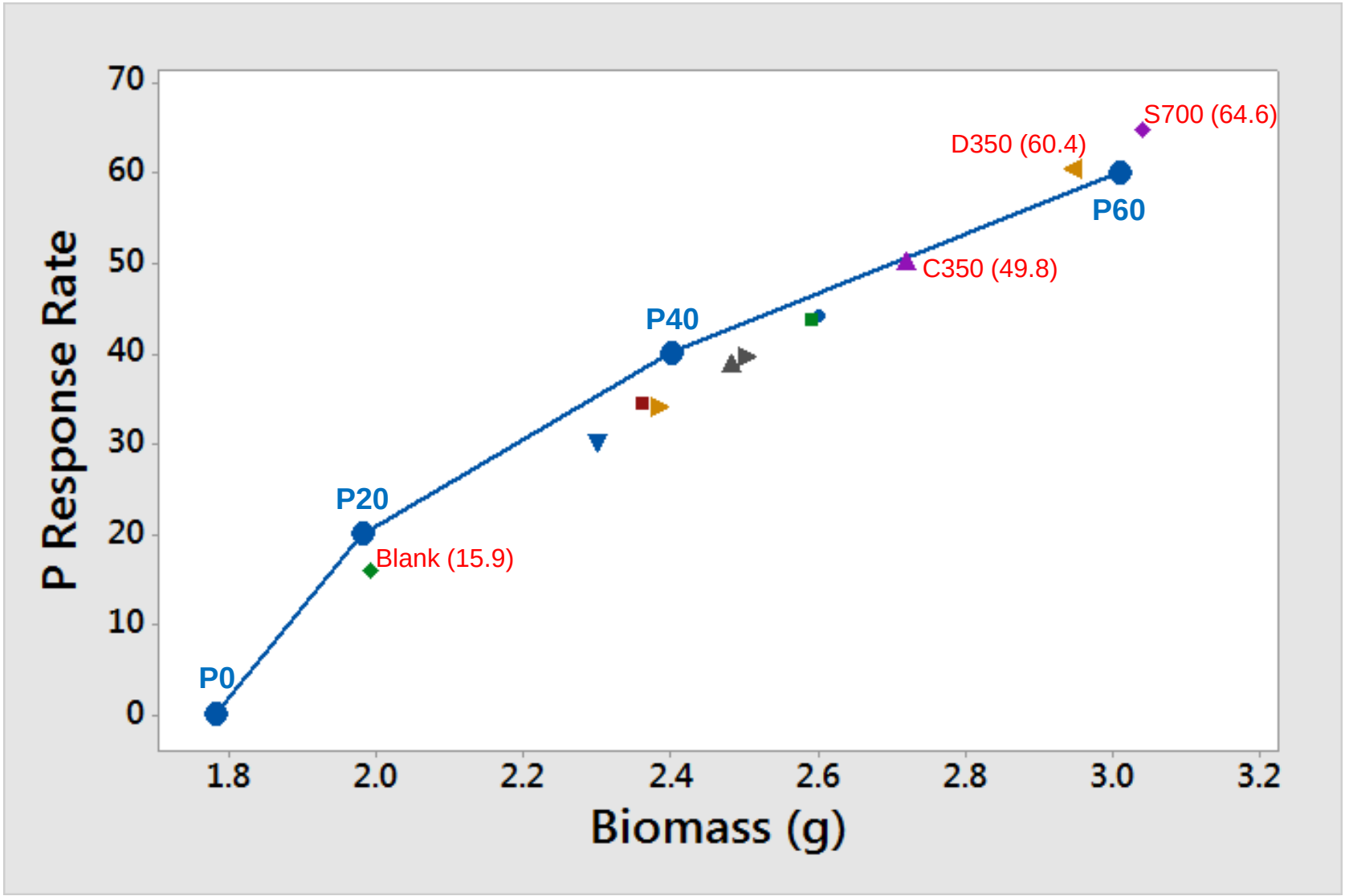
Correlations

Leaf Weight vs Leaf Area
$r = 0.979$ ($P = 0.0001$)

Leaf Weight vs Stem Weight
$r = 0.857$ ($P = 0.001$)

Stem Weight vs Leaf Area
$r = 0.795$ ($P = 0.003$)

Phosphorus Rate Results



P Rate = -76.3 + (46.35 x Biomass)

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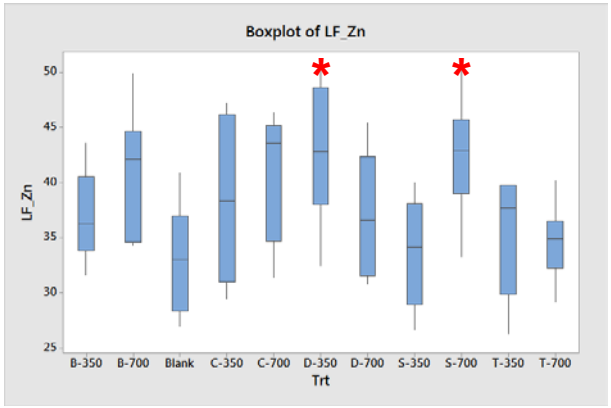
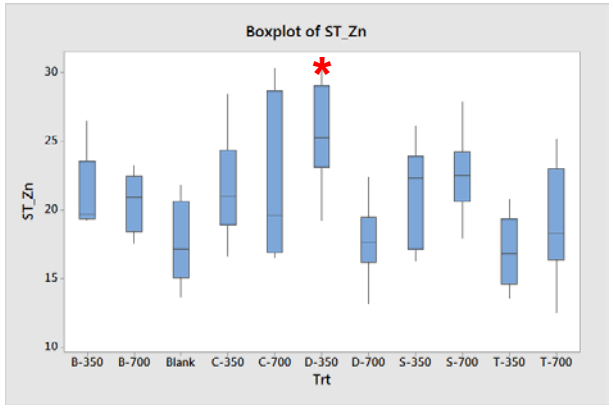
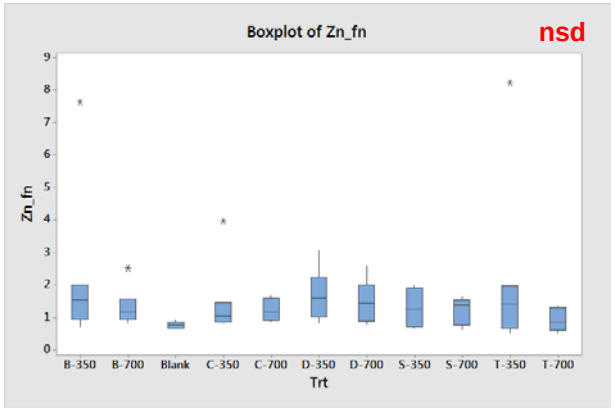
Nutrient Results

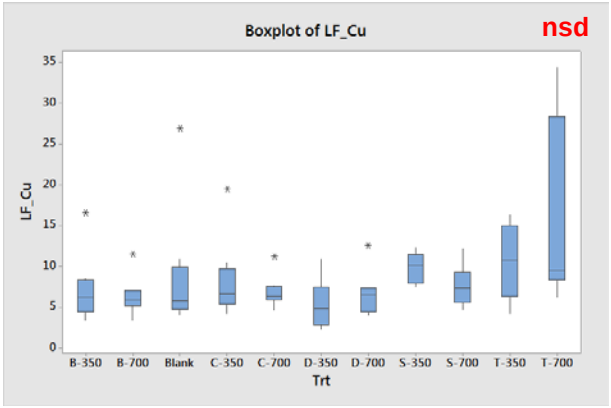
Zinc

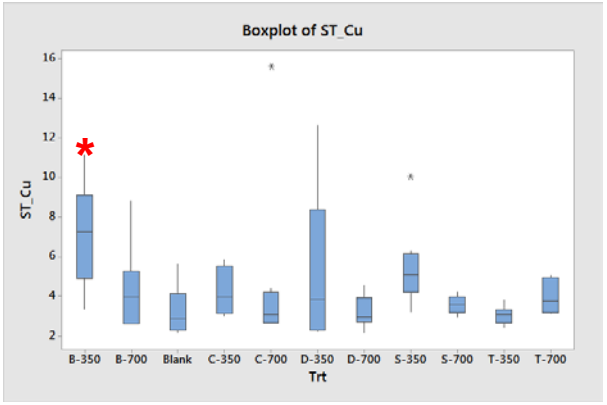


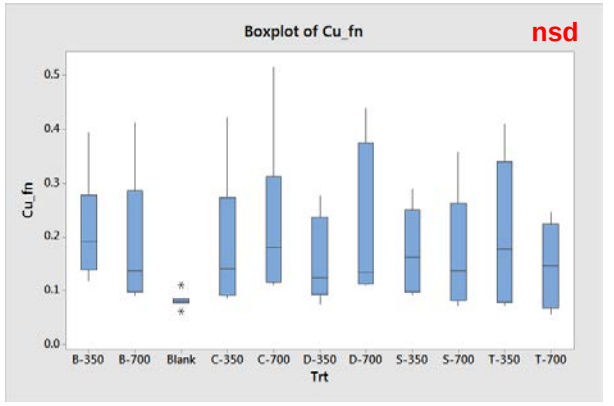




Copper







Leaf **Stem** **Soil**

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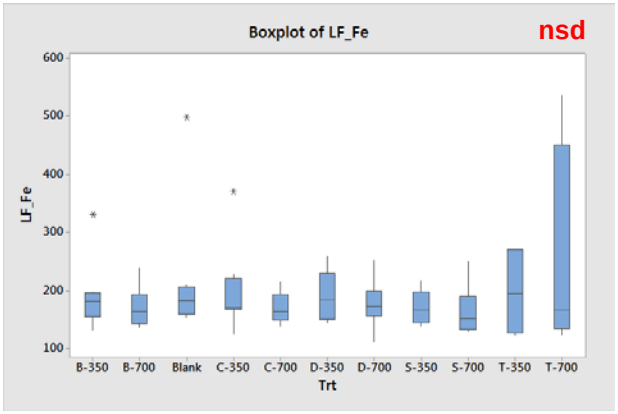
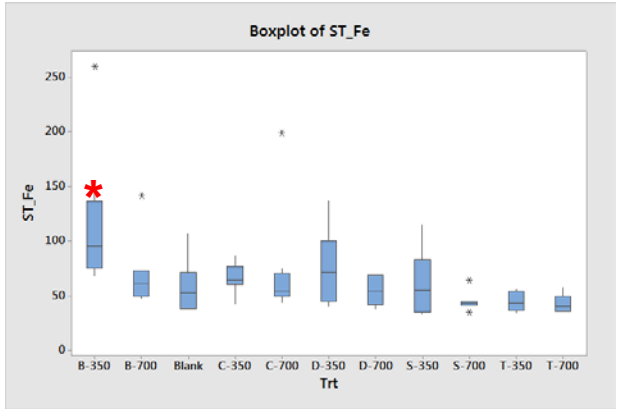
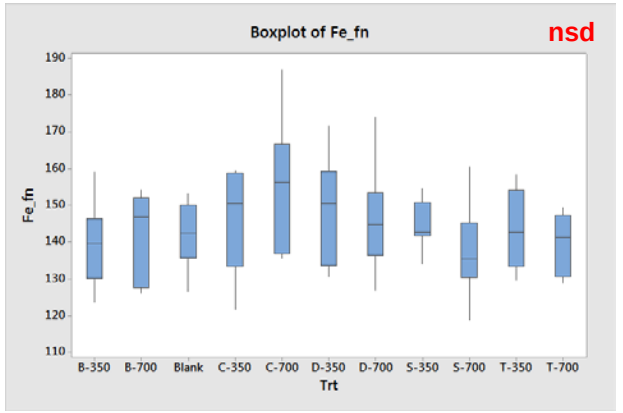
Nutrient Results (con't)

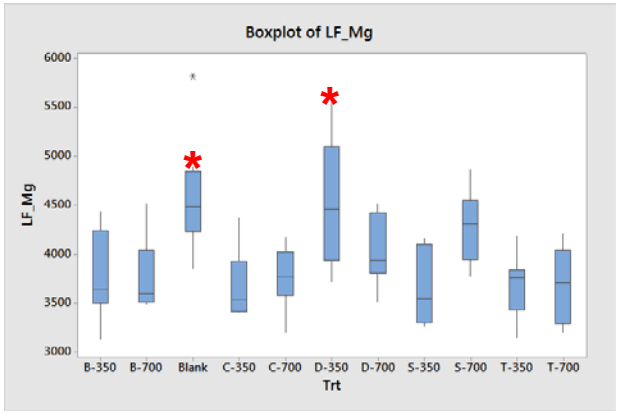
Iron

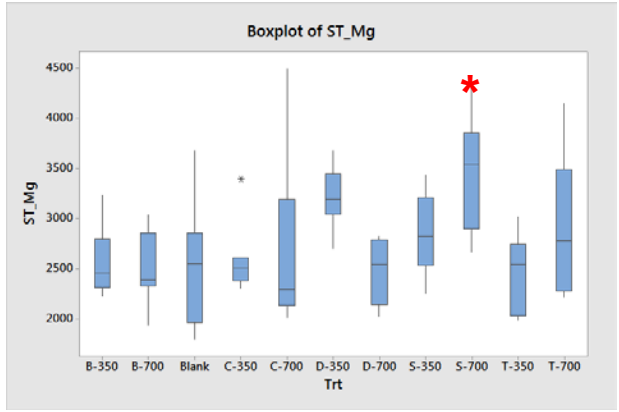


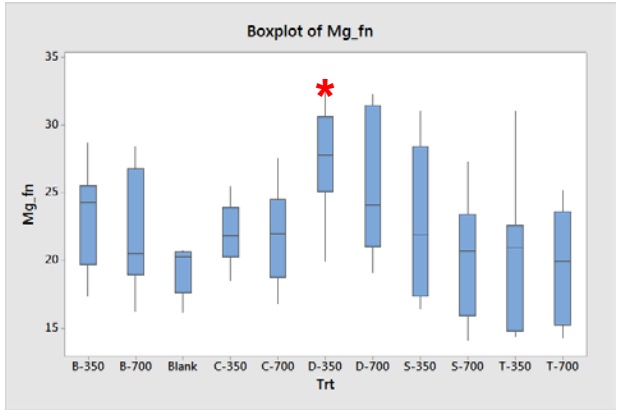




Magnesium







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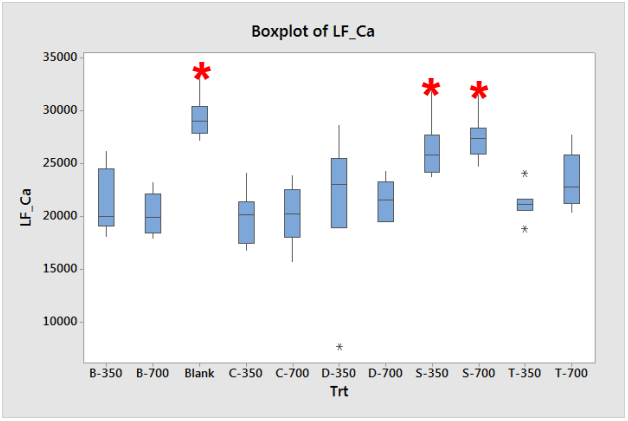
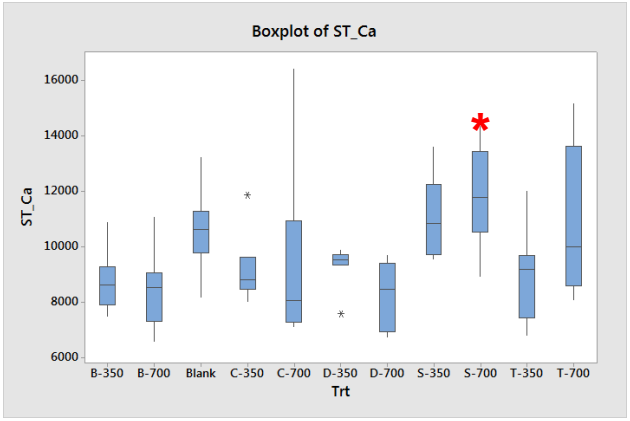
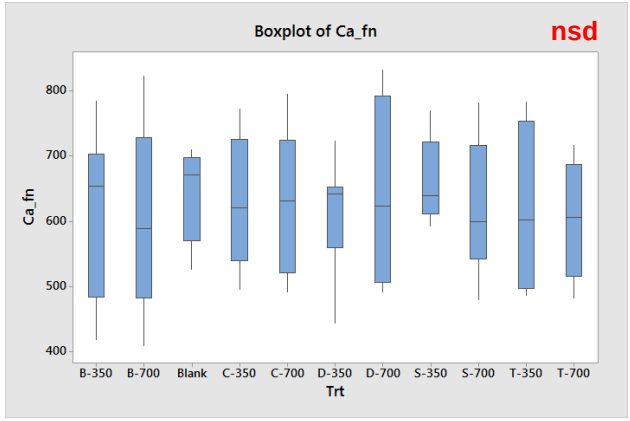
Yet More Nutrient Results

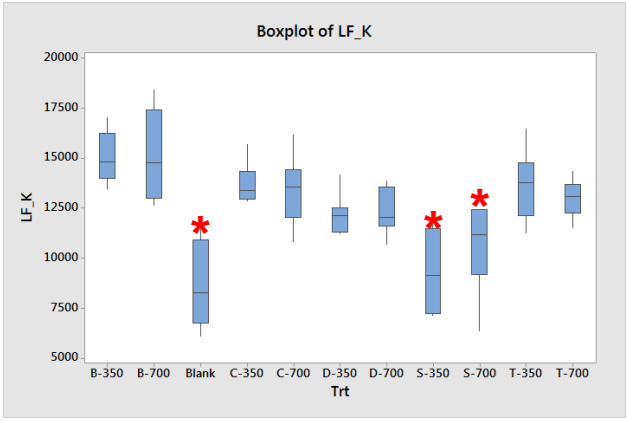
Calcium

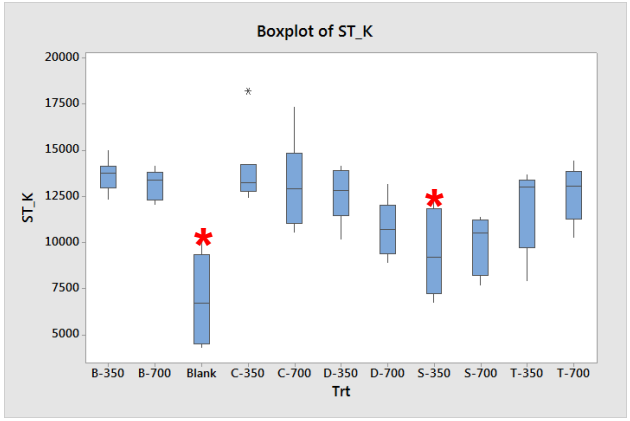


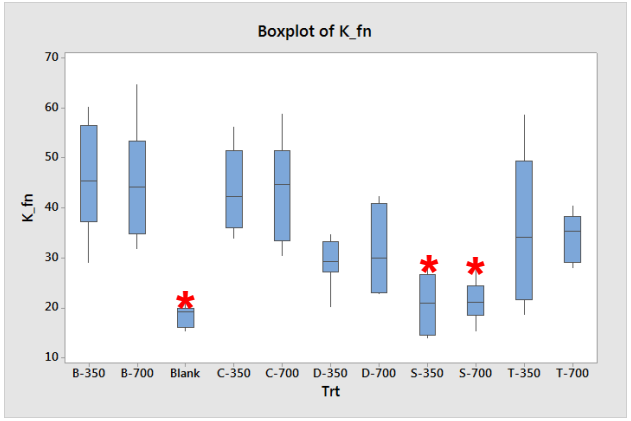




Potassium







Leaf **Stem** **Soil**

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Conclusions

- Manure-based biochars make effective P fertilizers
  - free of pathogens and ARB/ARG
  - equal to or greater P rate responses compared to P_2O_5
- Similar uptake rates to conventional fertilizers
  - macro- and micro- nutrients
  - no toxicity concerns
- Low addition rates
  - allow for coupling with other biochars for conditioning purposes