

Advancing the Circular Bionutrient Economy: Understanding the Salinity Issue Associated with Urine as a Fertilizer



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INTRODUCTION

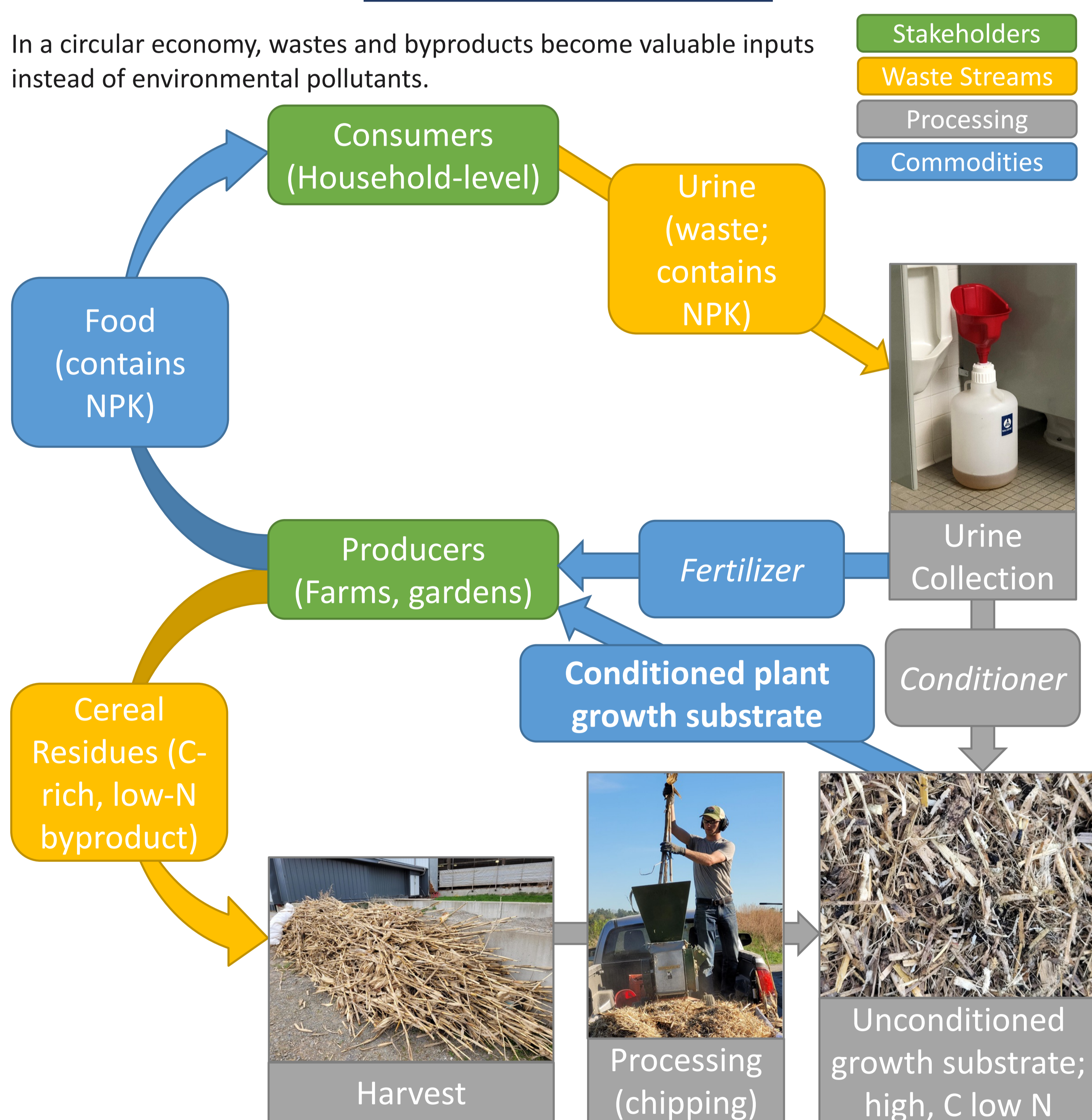
The world has a fertilizer problem, a soil health problem, and a sanitation problem, which together threaten food security, climate stability and global health. The Circular Bionutrient Economy (CBE) strives to address these triplet problems by reversing the linear nutrient flow from rural soils to urban diets and then via mostly untreated sewage to pollute our shared waterways.

Better management of human urine, and the nutrients abundant within it, can both offset the need for costly synthetic fertilizers and detain those otherwise wasted nutrients before reaching aquatic environments in the form of effluent. When coupled with organic underutilized resources (OURs) such as cereal residues like wheat straw and maize stover, human urine can enable urban growers to produce substantial food supplies safely, even where fertilizers or uncontaminated soils are not readily accessible.

To untap the fertilization potential of human urine, the risks need to be properly understood. While urine contains the nutrients most essential for plant growth — nitrogen (N), phosphorus (P), and potassium (K) — it also contains significant amounts of sodium (Na) and magnesium (Mg) salts that can elevate salinity to an extent that could potentially accumulate to levels toxic to plants.¹ The use of urine in soil-based systems has shown elevated salinity,^{1,2,3,4,5} but the use of urine in alternative substrates like chopped cereal residues remains largely unexplored.

THEORY OF CIRCULARITY

In a circular economy, wastes and byproducts become valuable inputs instead of environmental pollutants.



EXPERIMENTAL DESIGN

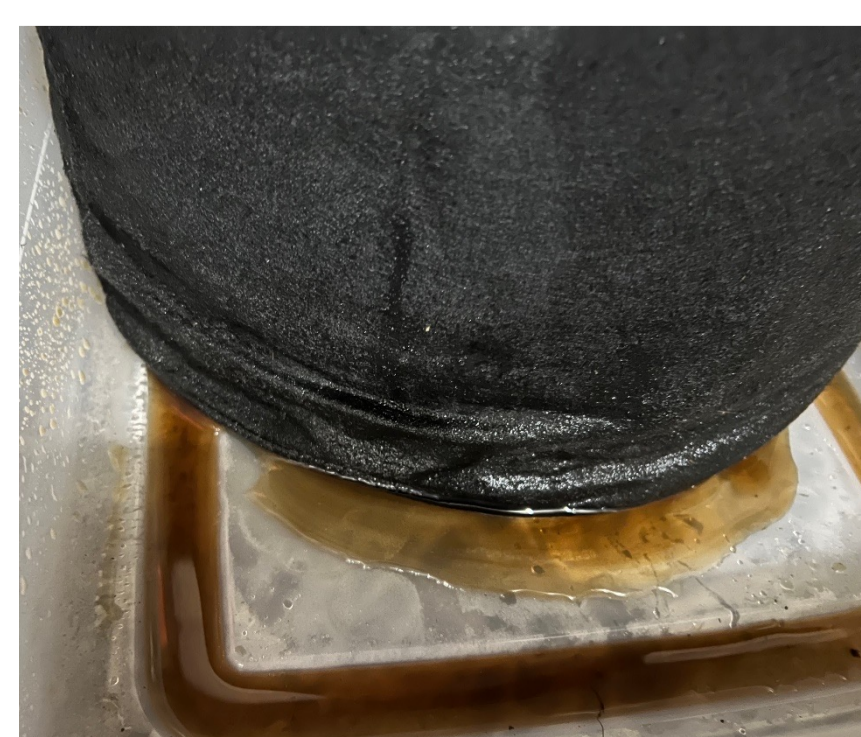


Treatment	Char	Char trt	"Condition"	Fertigate	no. pots
A	None	Water	Water	Water	3
B	None	None	Pee	(1/10)	4
C	Char (10%)	Water	Water	Water	3
D	Char (10%)	Water	Pee	(1/10)	4
E	Char (10%)	Pee - cold	Pee	(1/10)	3
F	Char (10%)	Pee - hot	Pee	(1/10)	3

20 Plum Perfect tomato plants were allocated across 6 treatments. C, D, E, F included 10% highly porous pyrolyzed organic matter (biochar). To end pyrolysis, the hot char is quenched with water (C, D) or urine (F) and for (E), soaked with urine when cold. Each sack was conditioned prior to planting with either urine (B, D, E, F) or water (A, C) and then fertigated with water (A,C) or 1:10 dilution of urine thereafter (B, D, E, F).

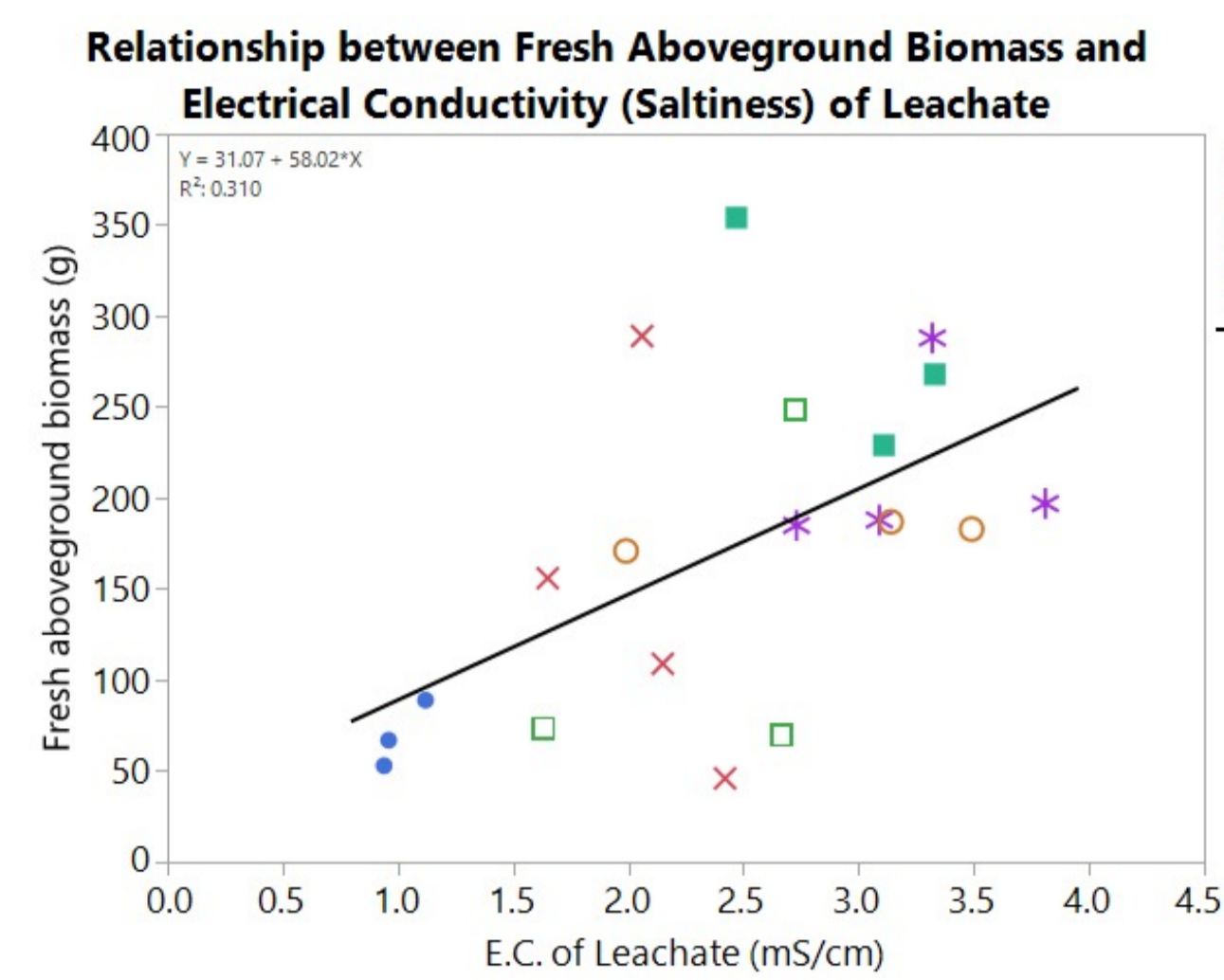


Plants laid out for biomass measurement. Each row is a different treatment: (A - F, front to back).



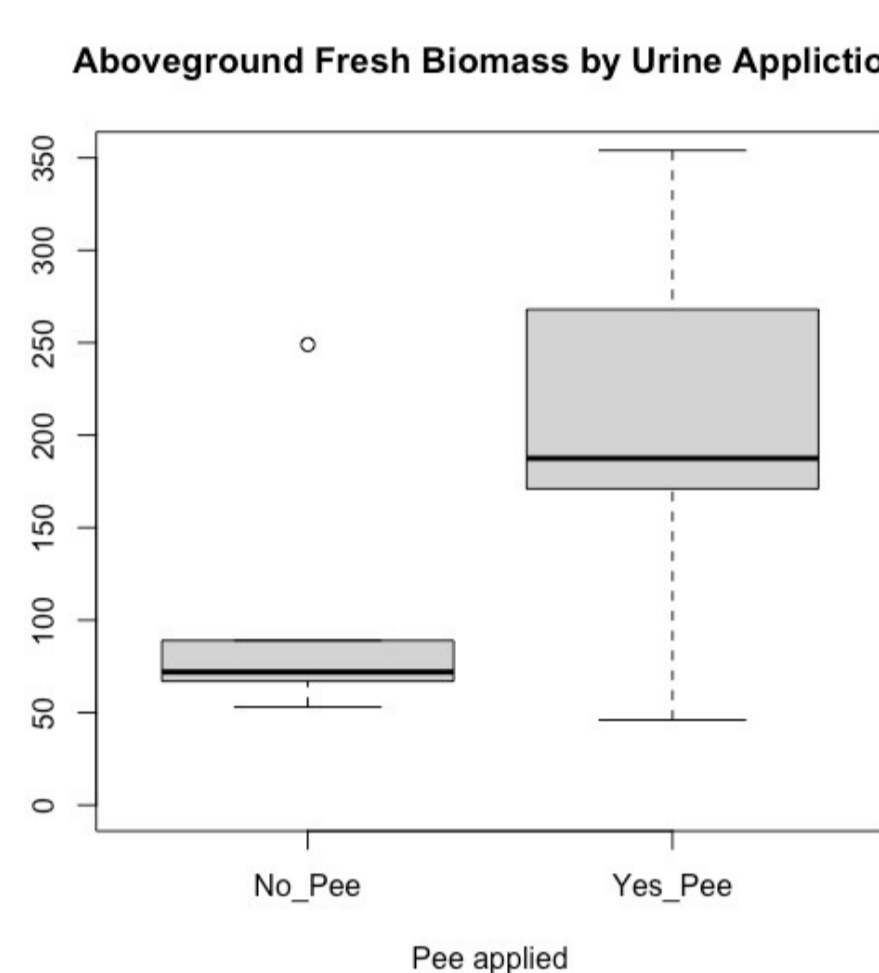
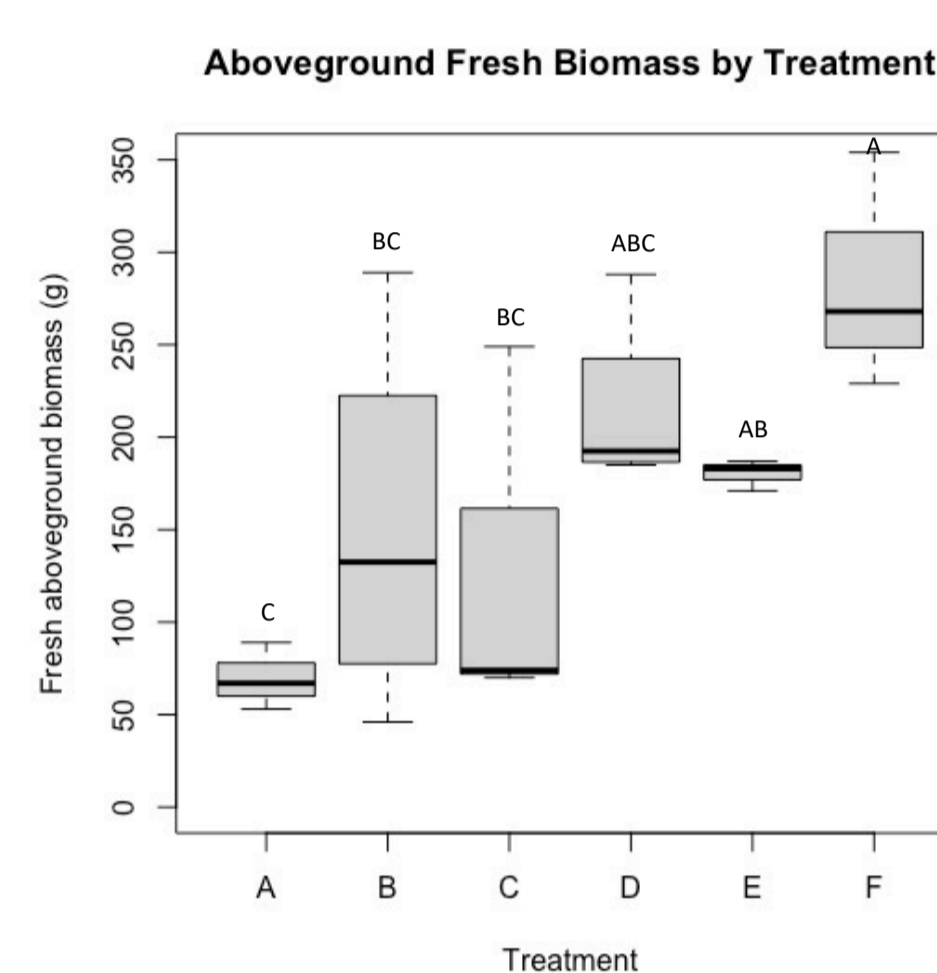
Flushing growth sacks with water to collect leachate.

RESULTS



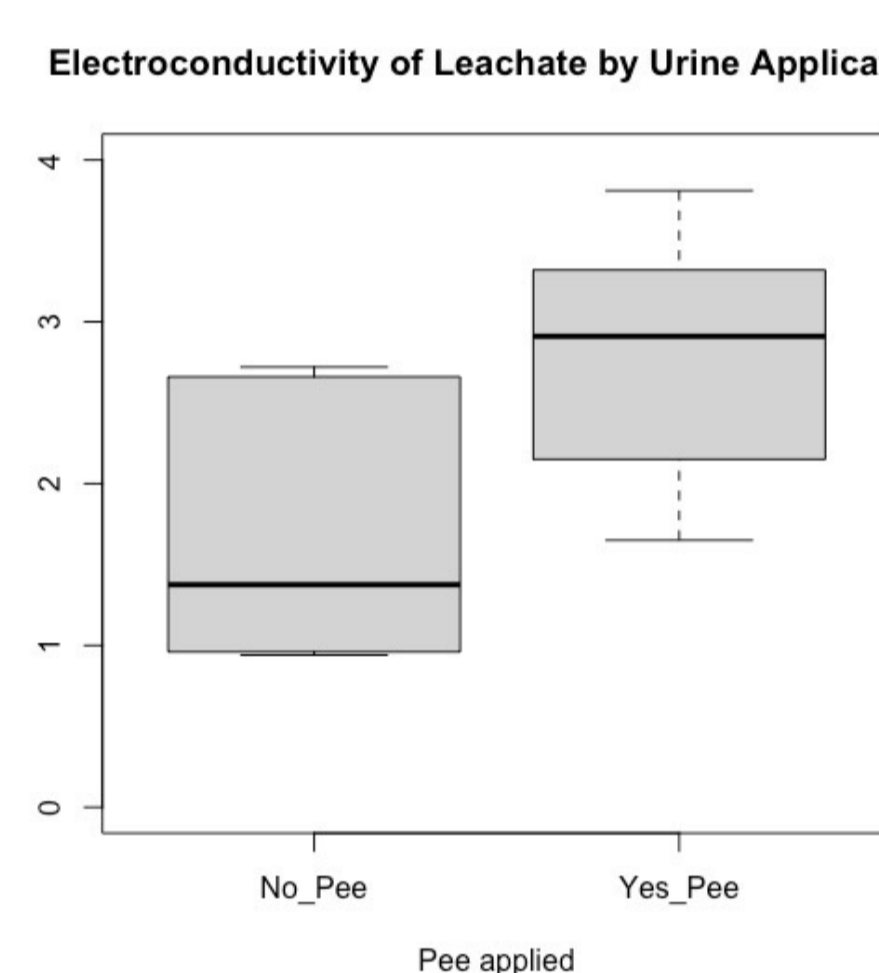
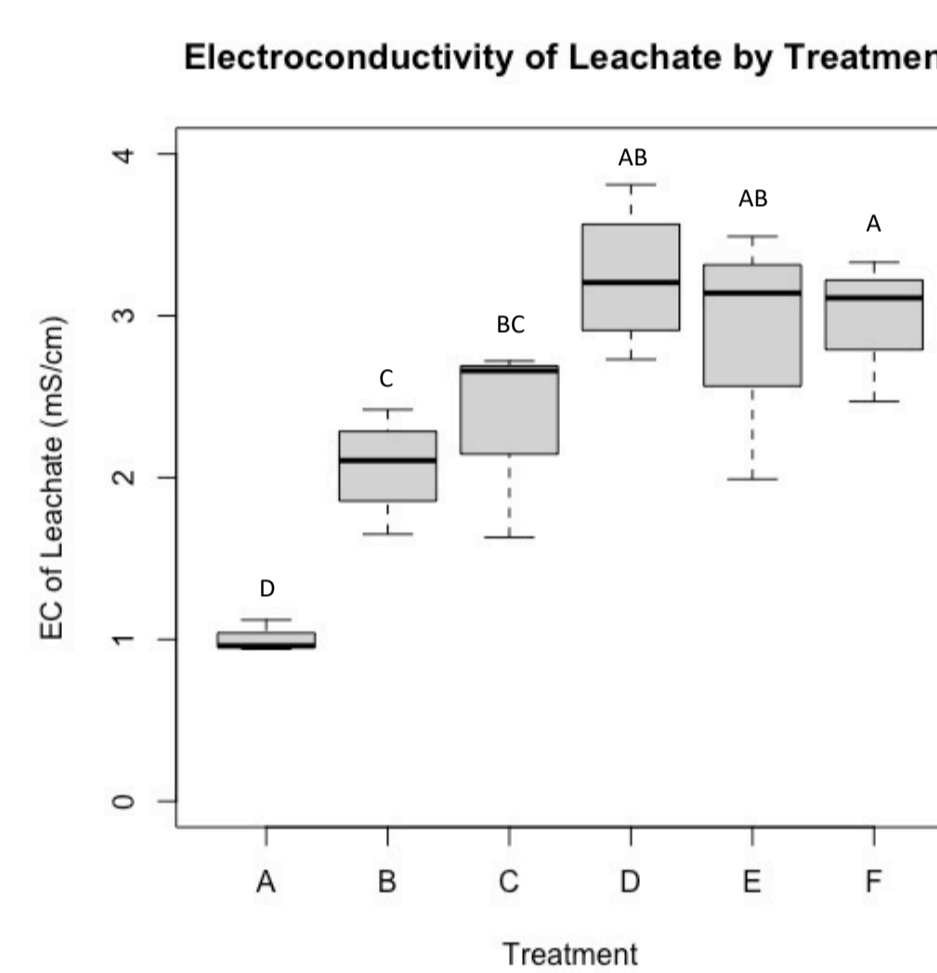
Electrical Conductivity (EC, used to measure salinity and ionic concentration) and plant biomass production are positively correlated within the EC range of 0.0-4.5 mS/cm.

Treatments D,E,F received both urine and biochar. Treatment B received urine, but not biochar. C received biochar, but not urine. A received water only.



Student's T-Tests found significant differences in aboveground biomass for the treatment groups.

The mean biomass for urine-fertigated treatments was 204g, which is 104g (95%CI = (24, 183)) higher than the mean biomass for water-irrigated treatments (100g).



Student's T-Tests found significant differences in leachate electroconductivity for the treatment groups.

CONCLUSIONS AND FURTHER INVESTIGATION

In a 3-month study growing tomatoes in chopped maize stover with variable biochar and urine application we find that urine-treated units significantly outperform those not fertilized with urine ($\alpha = 0.05$), as measured by fresh biomass. Additionally, we find that urine-treated units become significantly more saline than the control, as measured by leachate electrical conductivity (EC). Finally, we found that plant biomass and leachate EC have a positive correlation within the observed range of EC, and that the highest EC levels observed likely do not approach those that inhibit tomato performance.⁶

Further investigation is needed to understand the longer-term life stages of cereal residues-based substrates and salt accumulation over time. Additionally, controlled irrigation and flushing treatments are needed to indicate viability of this system in water-limited environments. This further investigation will be conducted under rain exclusion at Dilmun Hill Student Farm over several years.



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