Delineating Subsurface Phosphorus Flow in the Everglades Agricultural Area (EAA) Using Saturated Hydraulic Conductivity (K_{SAT})

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Introduction

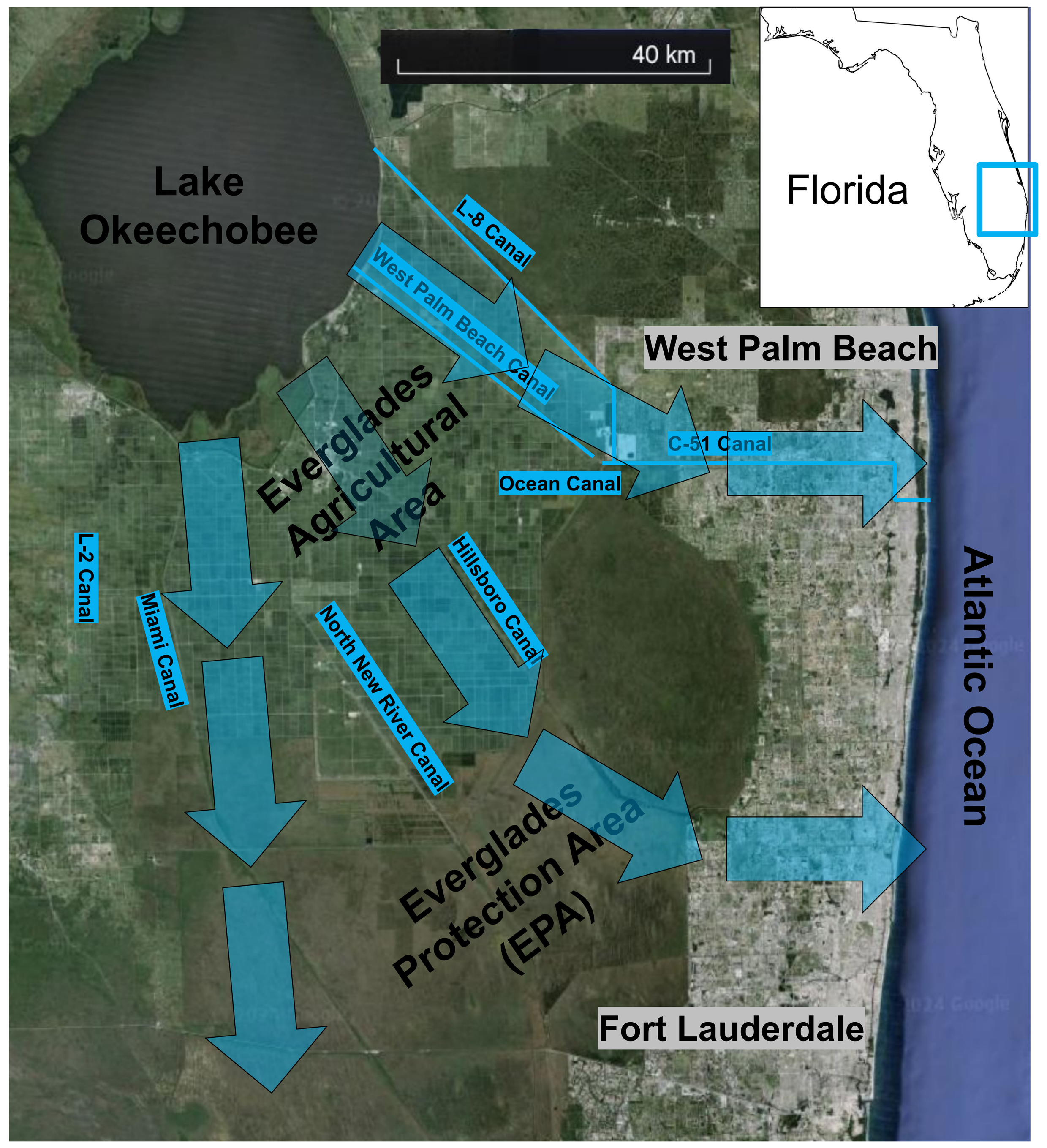

Figure 1: Water flow from Lake Okeechobee. Excess water from the lake flows through the canals in the Everglades Agricultural Area (EAA), and out into the Atlantic Ocean and Central and Southern Everglades.

- Everglades Agricultural Area (EAA) □ 3000 km^2
- Histosols characterized by high organic matter content
- Utilizes subsurface irrigation
- Subsurface phosphorus runoff leading cause of eutrophication (Mullins 2000)
- Saturated hydraulic conductivity (K_{SAT}) defines ability of saturated soil to transmit water □ useful in determining nutrient movement (USDA 2024)

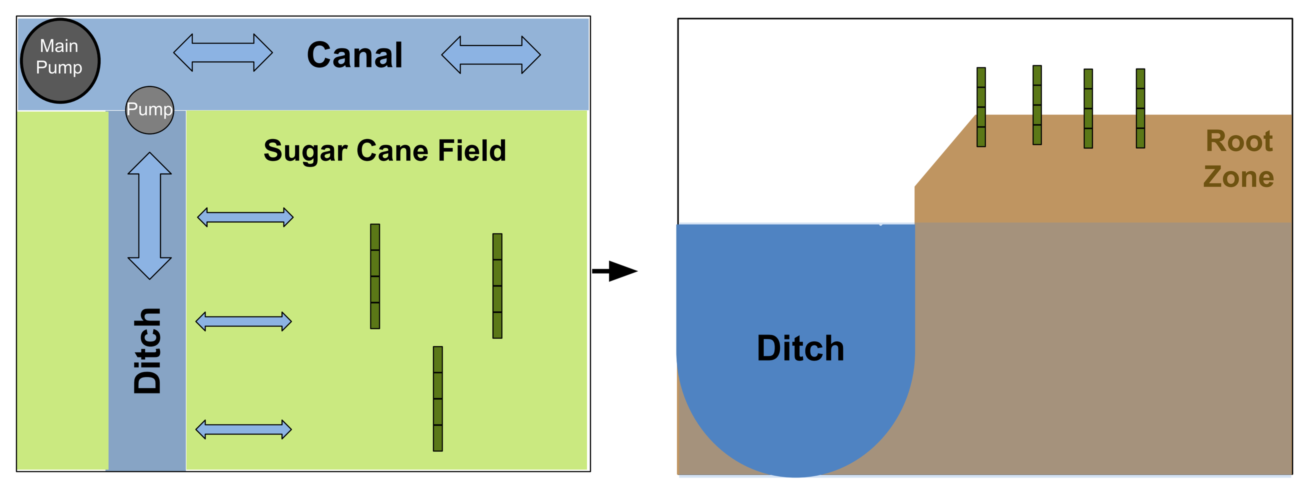

Figure 2: Subsurface irrigation through canal and ditch systems in the Everglades Agricultural Area. Blue arrows represent water flow.

Study Objective: To understand subsurface P flow from the EAA into adjacent canals using K_{SAT}

Hypotheses:
(1) K_{SAT} will be lower in the sugarcane fields than virgin land
(2) K_{SAT} will be higher in the ditches than in sugarcane fields
(3) Fields with higher K_{SAT} will have higher average of TP in adjacent ditches

Methods

Field Sampling

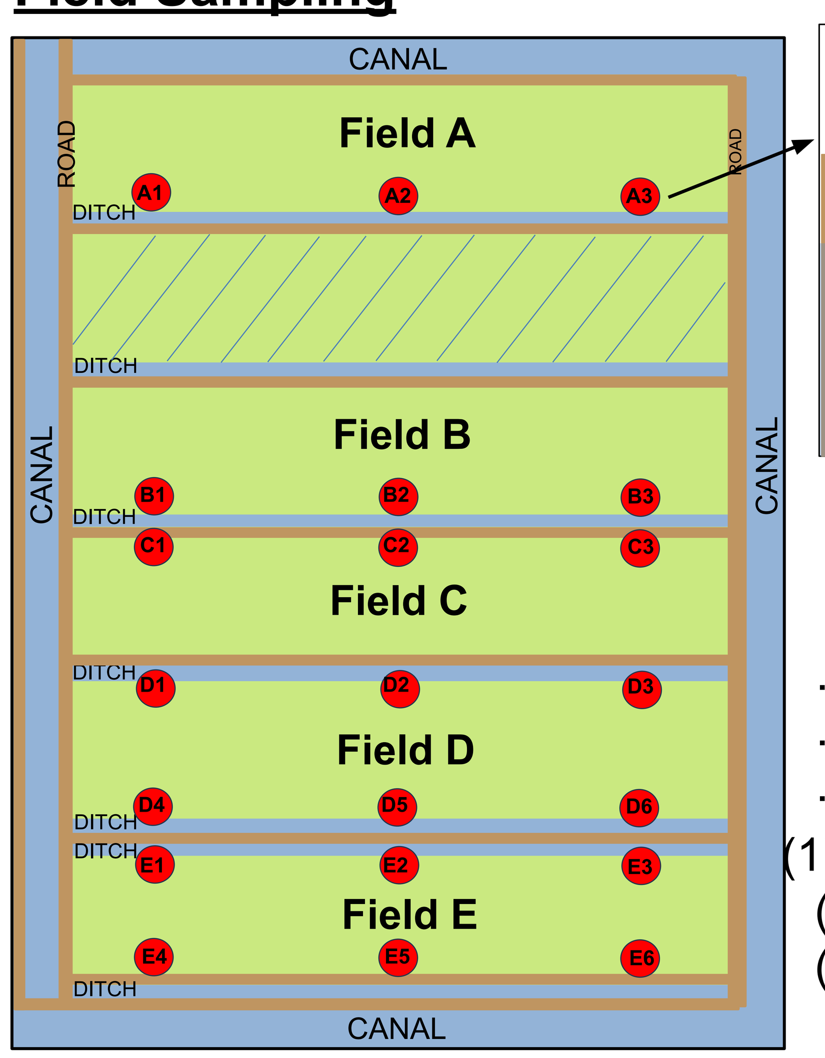

Figure 3: Layout of experimental and control fields. Red circles indicate each sample plot.

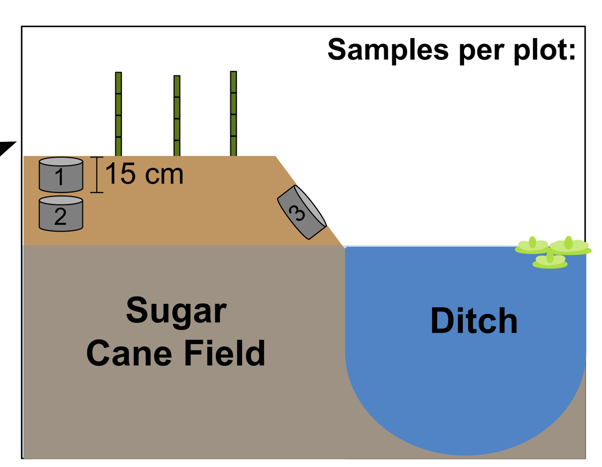

Figure 4: Soil sample locations per plot in relation to canal/ditch.

- 21 locations
- 60 total samples
- 3 samples per plot
(1) 0 – 15 cm,
(2) 15 – 30 cm
(3) ditch (above water table)

Laboratory Analysis

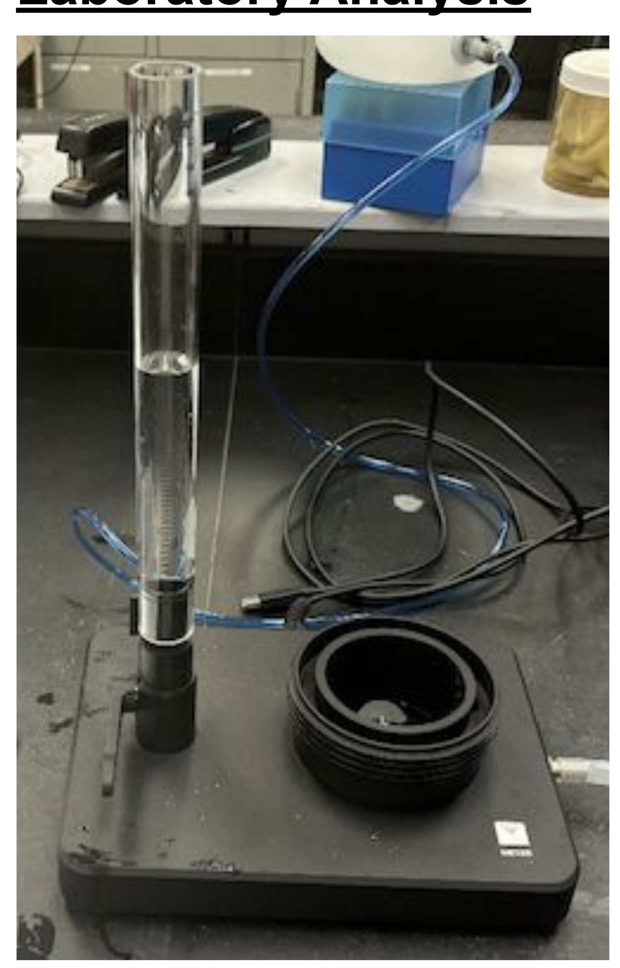

Figure 5: Image of METER K_{SAT}® device used to measure saturated hydraulic conductivity.

- METER K_{SAT}® device to measure saturated hydraulic conductivity
- Total phosphorus (TP) concentrations data in ditch water used from collections in 2022 and 2023.

Results

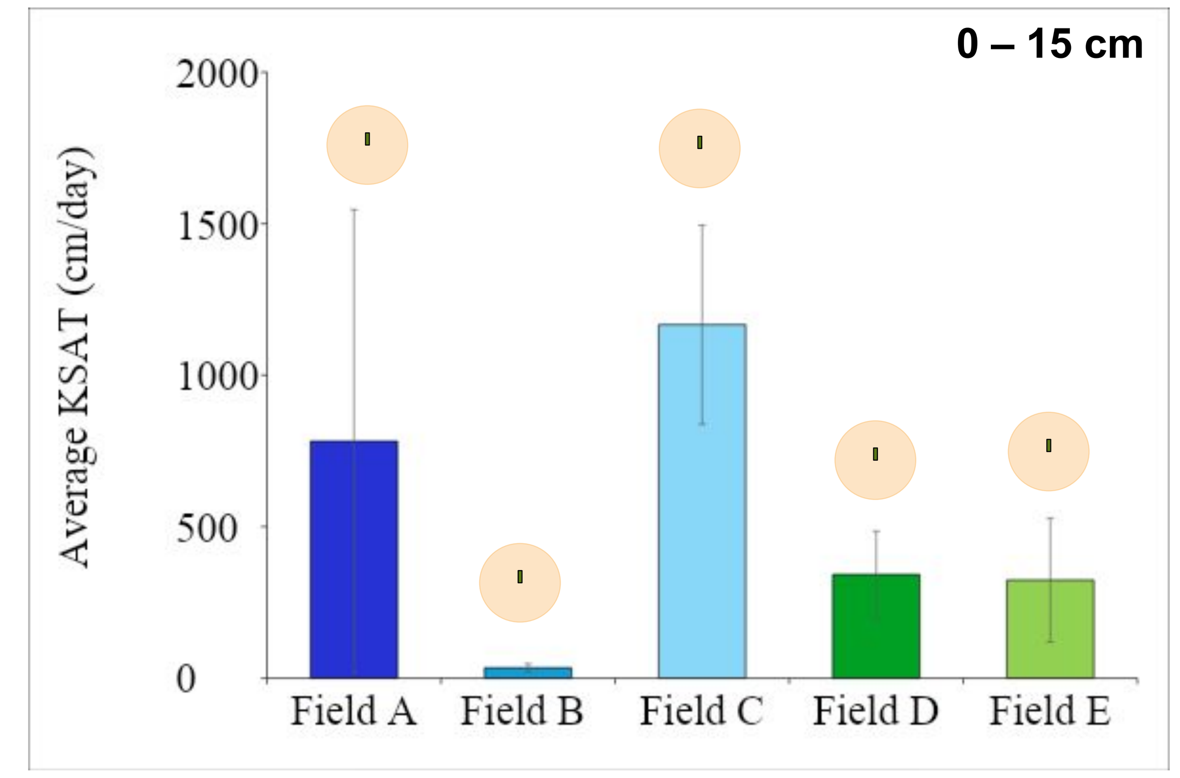

Figure 6: Average saturated hydraulic conductivity (K_{SAT}) of 0 – 15 cm soil samples in fields A - E. Grey bars indicate standard error.

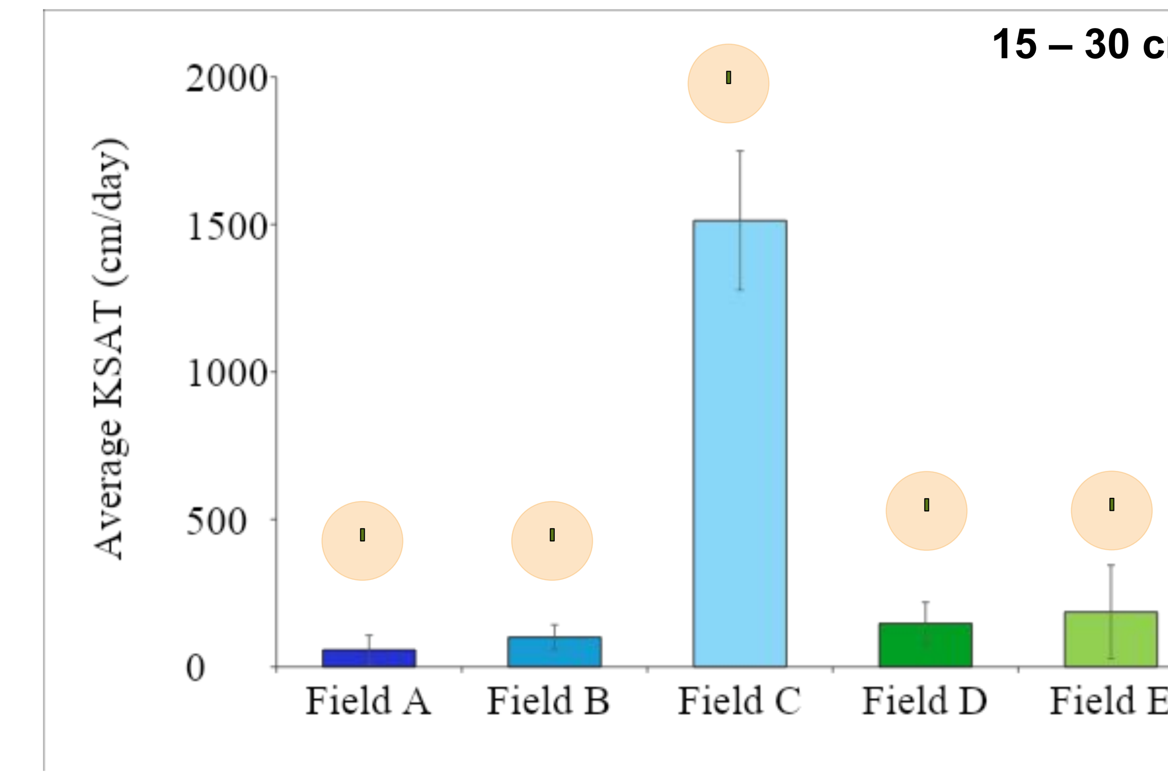

Figure 7: Average saturated hydraulic conductivity (K_{SAT}) of 15 – 30 cm soil samples in fields A - E. Grey bars indicate standard error.

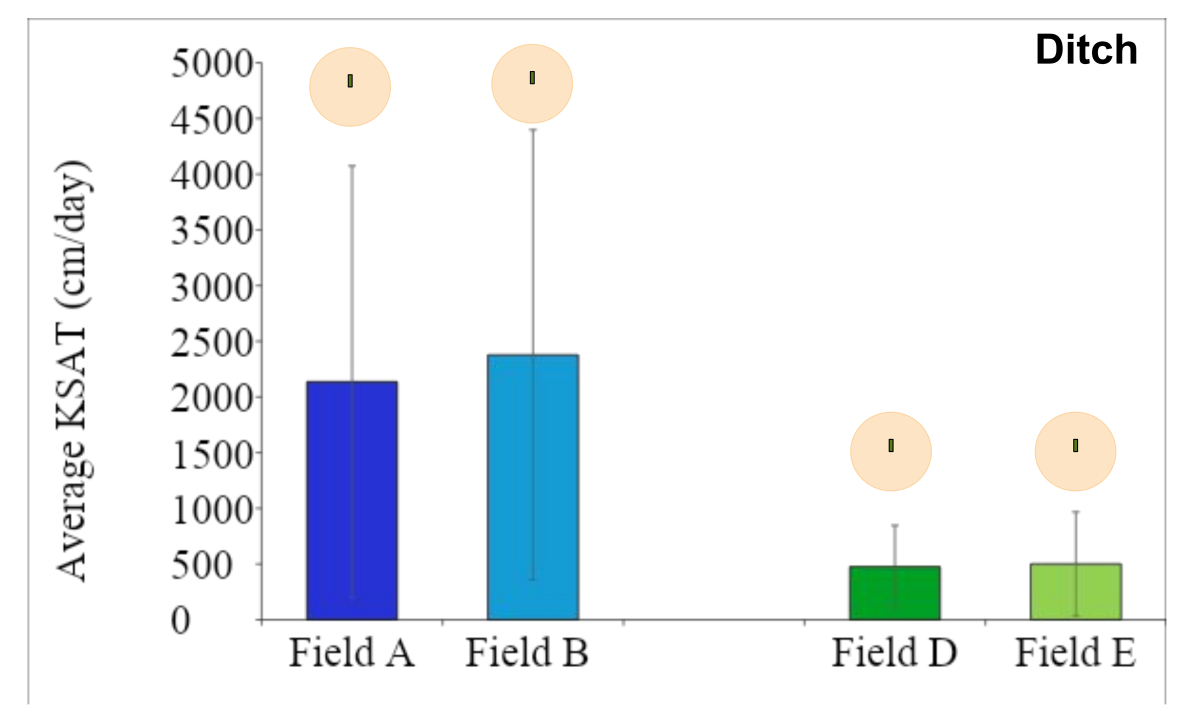

Figure 8: Average saturated hydraulic conductivity (K_{SAT}) of ditch soil samples in fields A - E. Grey bars indicate standard error.

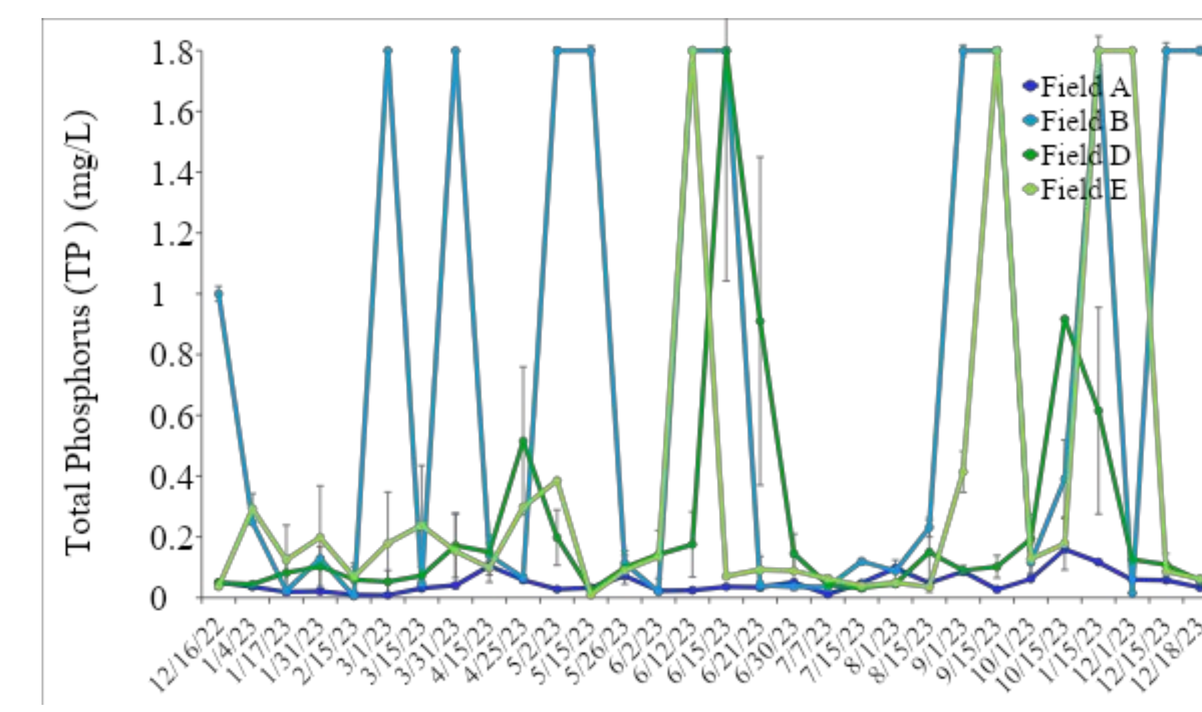

Figure 9: Average total phosphorus (TP) concentrations of ditches in fields A, B, D, and E from Dec. 2022 – 2023. Grey bars indicate standard error.

Discussion

- K_{SAT} values range from 1 cm/day to 6400 cm/day
- Fields B, D, and E have lower K_{SAT} values at 0-15 cm depth than control (Figure 6)
- Fields A, B, and E have lower K_{SAT} values at 15-30 cm depth than the control (Figure 7)
  - Sugar cane roots reduce pore space in soils as the plant grows (Zimmermann 2006)
- K_{SAT} values lower in 15-30 cm soil than 0-15 cm
  - Increased compaction with increased depth
  - Smaller pore spaces (Jabro 1992)
- K_{SAT} values higher in ditch soil than field soil
  - Ditch soils contain more minerals content
  - Field soils contain more organic content (Bottcher 1994)
- No statistical K_{SAT} differences between experimental fields or ditch samples
- Yearly TP average in Field D higher than Fields A and B
  - No statistical relationship with K_{SAT}, cannot reject null
  - Rationale: two ditches in Field D, one in Fields A and B

Conclusions

- First and second hypothesis supported; null of third hypothesis could not be rejected
- K_{SAT} data valuable for future subirrigation research, and additional subsurface phosphorus studies
- Can be used to develop conservative agricultural techniques to limit excess nutrient flow from farmlands

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