Spatiotemporal variability of soil fertility and nutrient uptake in rice soils: the role of flood water movement

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Introduction and Objectives

• Understanding the mechanisms driving spatiotemporal variability of yield within a field is necessary in order to predict and effectively manage it.

• We are investigating the relative importance of three management-driven factors - flood water movement, water temperature and laser-leveling - in driving spatiotemporal variability of yield across field scales.

• **Here we present results that focus on:**

- **the influence of flood water movement on the redistribution of soil nutrients within a field over time, and**
- **the impact of flood water movement on plant nutrient uptake and yield.**

Main Hypothesis

•Over time, flood water movement across a field redistributes soil nutrients from the top check (i.e., sub-field) to the bottom check, resulting in greater nutrient uptake and yield in the lower checks.

Methods

- 2-year on-farm study in 4 rice fields in the Sacramento Valley, ranging in size from 23 to 69 hectares
- At geo-referenced locations we measured,
  - Dissolved organic carbon (DOC), total nitrogen (N), soluble phosphorous (P) and soluble potassium (K) in flood water at 2 sampling times per year (i.e., **Time 1** = 2-6 days after initial flood, and **Time 2** = late-season)
  - Soil N, P, K and organic C (SOC) concentrations
  - Plant uptake of N, P and K
- Commercial yield monitors measured yield with a GPS.
- Nutrient omission trials to determine the spatial variability of N, P and K deficiencies and plant uptake.
- Water data from each field was analyzed individually using Restricted Maximum Likelihood (REML) to test the significance of distance in each linear mixed effect model.

(Photo above) Collecting soil samples after land preparation, and before fertilizer application.

(Photo above) Water moving from one check to the next through a rice box.

Water characteristics (2008 & 2009)

Do concentrations of DOC, total N, and soluble P and K in flood water increase with increasing distance from the inlets within a field?

Table 1. Summary of the significant water trends.

Chemical species	Field	Year	Increase or Decrease	Significance
DOC	Fields 1-4	'08/09	Increase	**
Total N	Field 3 Field 2	'08/09 '08	Increase Increase	** **
Soluble P	none[1]			
Soluble K	Field 1 Fields 2-4	'08/09[2] '08/09[3]	Decrease Increase	** **

[1] Soluble P was generally undetectable (<0.05 ppm) in all fields.
[2] Both years were significant during Time 2 only.
[3] Both years were significant during Time 1 only.

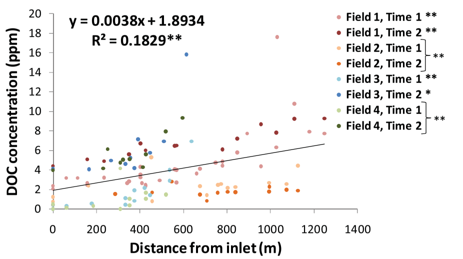


Fig. 1. Accumulation of DOC due to flood water movement across 4 fields. Both sampling times are identified for each field, and include 2008 and 2009 data.

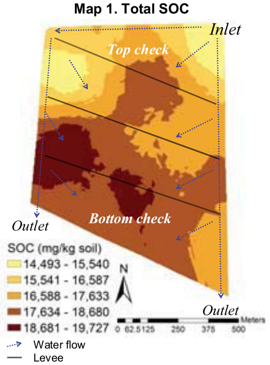
Soil characteristics (2008)

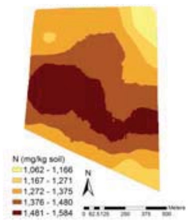
Do total SOC, total soil N, and extractable P and K increase with increasing distance from the inlets within a field?

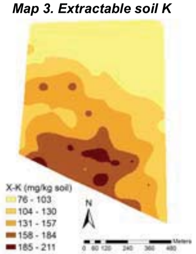
Table 2. Summary of the significant soil trends.

Chemical species	Field	Increase or Decrease	Significance
Total SOC	Field 1 Field 2 Field 4	Decrease Increase Increase	* ** *
Total N	Fields 2-4	Increase	**
Extractable P	Field 1 Fields 2-4	Decrease Increase	** **
Extractable K	Fields 2-4	Increase	**

Soil characteristics (2008) (Continued)





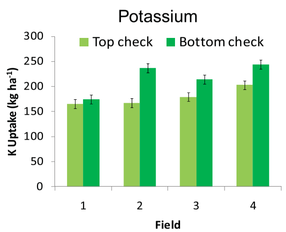


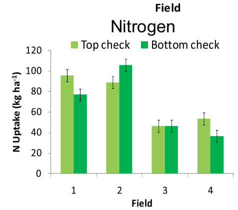
Maps 1 - 3. Field-scale trends of 2008 soil properties in **Field 2** obtained using ordinary kriging. Concentrations of total SOC, and total soil N, P and K generally increase with increasing distance from the inlet, following the flow of water across the field.

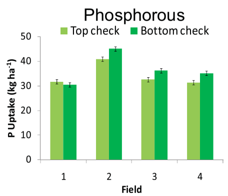
Nutrient uptake (2008)

Is plant nutrient uptake greater in the bottom check compared to the top check?

Fig. 3 . Comparison of plant uptake in top and bottom checks among fields . *The standard error, represented by the error bars, uses a pooled estimate of error variance.*





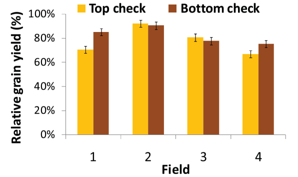


• **K uptake** was significantly **greater in the bottom checks** compared to the top checks (p=0.05*).
• There was generally greater **P uptake** in the bottom check as well, but the difference was not significant (p=0.12).
• The effect of field position on **N uptake** was mixed, and therefore there was no significant trend.

Yield (2008)

Is yield significantly greater in the bottom check compared to the top check within a field?

Fig. 4. Comparison among fields of the relative yield differences within each field. *The standard error, represented by the error bars, uses a pooled estimate of error variance.*



• There was no significant difference in yield between the top and bottom checks (Fig. 4).

Conclusions

- Solute concentrations generally increased with increasing distance from the inlets due to surface water movement across the fields.
- Soil nutrient concentrations were generally higher in the lower checks, which is likely due to the redistribution of soil nutrients by flood water movement.
- K uptake was greatest in the bottom checks.
- These results suggest that growers could manage the top and bottom checks differently within a field.
- There was not a significant difference in yield between the top and bottom checks, suggesting that water movement had no effect on yield due to adequate nutrient management. However, there may have been confounding factors masking a response to nutrient differences between the top and bottom check.
- Field-leveling, water temperature and weed presence are other factors we are investigating, which may further elucidate the observed yield patterns.

Acknowledgements

Financial support was provided by the Kearney Foundation. Thank you to the Agroecosystems Lab, especially Cesar and Kristen, for their tremendous support in the lab and field. Thank you to Ligia and Bob in the Six Lab, and Tad from the Horwath Lab for their technical assistance with the water analyses.

We are also very grateful for the cooperation of the rice growers, George Tibbitts, Charlie Mathews and Larry Maben, in this research.