Nitrogen, phosphorus, and potassium losses from flooded rice fields in northern California

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Introduction

- Historically, rice straw was burned after harvest in northern California. Air quality concerns and governmental regulations have reduced the burning of rice straw to less than 20% of rice acreage. Currently, most rice straw is incorporated after harvest and fields are flooded to enhance the decomposition of the straw.
- The incorporation of rice straw retains nitrogen (N), phosphorus (P), and potassium (K) within the soil system in a different manner than burning.
- The N, P, and K losses from rice field drainage are unquantified and may represent a major flux of nutrients from terrestrial to aquatic ecosystems.

Objectives

- Compare losses and seasonal flow-weighted (FW) concentrations of total dissolved nitrogen (TDN), phosphorus (DP), and potassium (K) between burned and incorporated fields.
- Evaluate seasonal trends of TDN, DP, and K concentrations in rice field drain flow.

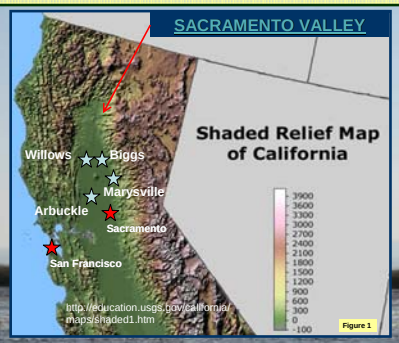
Materials and Methods

- **Four grower sites (blue stars, Fig. 1), two fields at each site (straw-burned and straw-incorporated)**
- **Rectangle weirs installed at each outlet (Fig. 2) to measure flow rates; samples collected weekly.**
- **TDN was measured by combustion; nitrate (NO_3-N) and ammonium (NH_4-N) were measured colormetrically; DP was measured spectro-photometrically (ascorbic acid method); and K was measured with atomic emission spectrometry.**

Table 1. Field size, rice variety, fertilizer rates, and soil characteristics (based on fall sampling)

Site	Field	Size	Variety	Fertilizer Rate N	P	K	N	Olsen-P	K
		ha		kg ha^{-1}			%	mg kg^{-1}	
Marysville	Burn	24	Koshi	30	28	53	0.1	15	33
Marysville	Incorp	27	Koshi	30	28	53	0.1	22	65
Biggs	Burn	58	M205	180	16	22	0.1	9	182
Biggs	Incorp	42	M206	180	16	22	0.1	5	169
Arbuckle	Burn	68	M206	101	0	0	0.2	9	189
Arbuckle	Incorp	52	M202	101	0	0	0.2	6	188
Willows	Burn	32	M205	108	17	32	0.2	10	151
Willows	Incorp	45	M205	108	17	32	0.2	14	238

Materials and Methods



Results – Growing-Season 2006

Table 3. Seasonal export of water and losses and flow-weighted concentrations (FW) of total dissolved nitrogen (TDN), dissolved phosphorus (DP), and dissolved potassium (K).

Grower	Field	Flow	Total Dissolved Nitrogen (TDN) Loss	TDN FW-conc	Dissolved Phosphorus (DP) Loss	DP FW-conc	Dissolved Potassium (K) Loss	K FW-conc
		Megaliters ha^{-1}	kg ha^{-1}	mg L^{-1}	kg ha^{-1}	mg L^{-1}	kg ha^{-1}	mg L^{-1}
GROWING SEASON 2006								
Marysville	Burn	2.0	0.8	0.2	0.1	<0.1	1	0.3
Marysville	Incorp	4.6	0.8	0.4	0.1	<0.1	6	3.1
Biggs	Burn	4.7	1.2	0.4	0.4	0.1	4	1.2
Biggs	Incorp	3.1	1.0	0.2	0.5	0.1	6	1.3
Arbuckle	Burn	2.3	1.5	0.5	1.8	0.5	8	2.4
Arbuckle	Incorp	3.3	1.6	0.7	0.4	0.2	4	1.7
Willows	Burn	1.3	0.2	0.7	<0.1	0.1	1	1.5
Willows	Incorp	0.3	1.1	0.9	0.2	0.1	3	2.5
WINTER 2006-2007								
Marysville	Burn	10.7	3.1	0.3	5.6	0.5	82	7.6
Marysville	Incorp	1.0	1.1	1.2	0.3	0.3	7	7.0
Biggs	Burn	<0.1	0.0	0.0	<0.1	0.1	<1	4.0
Biggs	Incorp	6.2	7.9	1.3	2.7	0.4	38	6.2
Willows	Incorp	0.7	0.7	1.1	0.2	0.3	4	5.8

There was not a significant effect of straw management on losses and FW concentrations of TDN, DP, and K.

Total Dissolved Nitrogen

Seasonal losses were low (<2 kg ha^{-1} N), except when there flow exceeded 5 ML ha^{-1} during the winter.

NO_3-N concentrations in outflow were typically less than 0.5 mg L^{-1} and only two samples were greater than 2 mg L^{-1}.

Ammonium (NH_4-N) concentrations were typically less than 0.5 mg L^{-1} and never exceeded 2 mg L^{-1}.

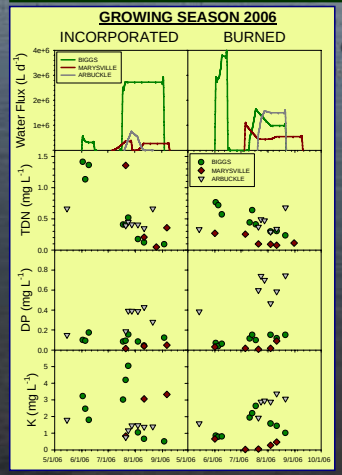
Dissolved Phosphorus

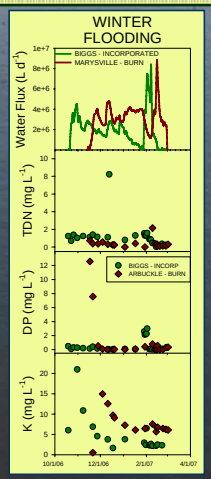
FW-concentrations in outflow were the greatest during the growing season in a field where no P was applied.

Potassium

Seasonal losses of K represent a major flux of K in these terrestrial ecosystems.

Results – Seasonal Trends





- TDN concentrations in outflow typically decrease during the growing season
- TDN concentrations during winter flooding were similar to those during the growing season, but occasional spikes related to flow increases did occur.
- DP concentrations in outflow were the greatest in fields were no P was applied.
- There was no apparent trend in DP concentration during the growing season.
- During winter flooding, P concentrations occasionally increased when the daily flow rate increased.
- K concentrations in outflow may be affected by the drainage flow rate.
- There does not appear to be a consistent effect of straw management on seasonal trends in TDN, DP, or K concentrations.

Conclusions

- The change in straw management practice from burning to straw incorporation with winter flooding does not have a major effect on seasonal losses of TDN, DP, or K in outflow.
- Water management and soil conditions at each site likely play a larger role in dissolved nutrient losses than straw management.
- Growing season losses of TDN and DP from rice field drainage do not represent major losses of N and P applied as fertilizer.
- The mineral N component (NO_3-N and NH_4-N) may represent only a small fraction of the total dissolved nitrogen.
- Dissolved K losses represent a large portion of the terrestrial K cycle.

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