SUPPLEMENTAL MATERIAL

Degree of phosphorus saturation as a predictor of redox-induced phosphorus release from flooded soils to floodwater

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Supplemental Table S1. Initial soil physical and chemical properties (Values are means of two replicates).

Soil series/	Clay	Sand	pH	EC†	OM†	CEC†	Olsen P	$M3P_{MRP}$†	$M3P_{TP}$†	P_{150}†	PSI†	Mehlich extractable (mg kg^{-1})				
treatment	%	%		dS m^{-1}	%	$cmol_c$ kg^{-1}	mg kg^{-1}				L kg^{-1}	Al	Ca	Mg	Fe	Mn
Ex situ mescosm study 1																
Almasippi	13	76	8.2	0.9	3.3	15.6	17.6	39.7	52.1	303	144.3	288	4576	498	86	83
Arborg	67	10	7.4	1.8	6.4	37.6	84.7	62.9	65.9	665	355.8	3610	6337	648	264	50
Fyala 1	42	26	7.7	1.5	17.0	43.1	40.0	79.4	88.3	607	315.9	568	8832	716	276	34
Lakeland 1	32	36	7.9	1.1	8.5	29.3	45.9	66.3	73.4	646	351.7	435	8279	657	133	82
Lakeland 2	42	28	7.7	1.3	11.0	40.9	19.4	15.0	21.1	670	310.5	375	8484	701	87	50
Long Plain	13	76	7.7	1.2	4.0	20.4	25.6	27.6	44.1	295	146.4	269	5168	202	130	87
Newdale	27	44	7.6	0.7	6.0	18.5	25.0	37.8	45.5	324	153.2	1947	4816	324	99	242
Niverville	37	36	7.7	1.4	7.8	33.7	36.1	49.5	54.3	460	227.2	115	8066	610	90	116
Osborne 1	58	14	6.4	1.2	8.4	46.3	60.3	76.5	81.9	493	242.6	3124	5105	517	221	53
Reinland	11	78	7.6	0.7	3.4	15.2	16.1	24.1	47.8	148	64.8	1160	3263	198	91	153
Scanterbury 1	74	6	7.6	1.2	5.6	50.9	29.5	27.3	29.3	770	408.8	2589	8642	649	170	45
Sprague	16	64	7.7	1.1	3.8	16.5	36.0	19.2	27.6	418	170.7	649	4398	262	193	50
Ex situ mescosm study 2																
Balmoral	42	38	8.3	1.8	9.2	49.2	16.7	26.9	35.7	563	279.4	1192	6960	1097	60	50
Dencross 1	43	17	7.9	0.9	18.1	77.3	65.1	136.7	196.6	388	186.2	822	4692	1833	47	99
Dencross 2	45	22	7.7	1.6	10.6	56.3	112.9	140.3	199.4	338	160.8	887	7062	1176	48	110
Denham	15	70	5.1	1.6	7.5	21.1	25.3	40.6	68.5	341	162.4	1425	2010	386	209	56
Fyala 2	60	36	7.6	2.0	16.9	84.4	7.6	13.4	16.7	650	329.1	1003	5841	1998	111	19
Marquette	54	27	7.9	4.0	16.8	84.4	203.2	202.5	215.2	756	393.3	934	6622	1264	42	45
Osborne 2	73	12	8.2	0.9	9.7	70.3	26.2	41.4	54.7	544	269.0	916	9077	1493	68	28
Pembina	26	34	6.2	0.6	9.3	70.3	22.4	17.3	24.6	363	173.5	1160	3769	501	122	115
Red River 1	66	16	8.0	1.2	11.0	70.3	12.6	15.7	17.5	666	338.3	1256	6532	1511	74	62
Red River 2	78	14	7.9	1.2	12.3	77.3	64.6	106.6	112.7	584	291.6	1274	6132	1107	51	41
Red River 3	68	17	7.4	1.4	13.2	70.3	166.7	199.8	293.0	463	225.2	1259	5092	1595	96	34
Scanterbury 2	64	19	6.4	1.1	14.6	77.3	48.4	48.6	68.8	425	205.7	1125	4586	1491	96	27
Scanterbury 3							**In situ mesocosm study**									
Control	60	10	7.5	1.1	3.7	43.0	13.0	16.9	21.9	777	420.6	840	6702	1905	302	51
Fertilized	Nd[a]	Nd	Nd	Nd	Nd	Nd	22.6	35.0	44.9	723	384.9	875	6352	2156	289	49
Manured	Nd	Nd	Nd	Nd	Nd	Nd	16.2	30.4	39.1	747	400.1	880	5776	1906	308	59

† EC- Electrical conductivity; OM- organic matter; CEC- Cation Exchange Capacity; $M3P_{MRP}$ - Mehlich extractable molybdate reactive P; $M3P_{TP}$ - Mehlich extractable total P; P_{150} – Single point P sorption capacity; PSI – Phosphorus saturation index; Nd- Not determined

Supplemental Table S2. Degree of P saturation (DPS, %) calculated using different equations (Eq 1- 15) for soils used in field mesocosm studies

Soil series/ treatment	DPS_1	DPS_2	DPS_3	DPS_4	DPS_5	DPS_6	DPS_7	DPS_8	DPS_9	DPS_{10}	DPS_{11}	DPS_{12}	DPS_{13}	DPS_{14}	DPS_{15}
Ex situ mescosm study 1															
Almasippi	2.8	6.2	7.9	3.4	7.3	9.3	5.8	13.1	17.2	5.7	12.1	15.3	12.2	27.5	36.1
Arborg	6.0	4.5	4.7	10.8	8.3	8.6	12.7	9.5	9.9	10.6	8.1	8.5	23.8	17.7	18.5
Fyala 1	3.2	6.1	6.8	4.0	7.7	8.5	6.6	13.1	14.6	6.0	11.2	12.3	12.7	25.1	28.0
Lakeland 1	3.4	4.9	5.4	4.9	6.9	7.6	7.1	10.3	11.4	6.1	8.6	9.4	13.1	18.9	20.9
Lakeland 2	1.4	1.1	1.6	2.1	1.6	2.2	2.9	2.2	3.2	3.0	2.4	3.3	6.2	4.8	6.8
Long Plain	4.2	4.5	6.9	4.6	4.9	7.6	8.7	9.3	14.9	8.0	8.6	13.1	17.5	18.9	30.1
Newdale	3.7	5.5	6.6	4.6	6.9	8.1	7.7	11.7	14.0	7.5	11.0	12.9	16.3	24.7	29.7
Niverville	3.8	5.1	5.6	4.0	5.4	5.9	7.8	10.8	11.8	7.4	9.8	10.7	15.9	21.8	23.9
Osborne	5.8	7.2	7.7	9.7	12.0	12.7	12.2	15.5	16.6	11.1	13.6	14.4	24.9	31.5	33.8
Reinland	5.2	7.5	13.9	4.4	6.5	12.1	10.9	16.3	32.3	11.1	15.7	26.9	24.8	37.2	73.8
Scanterbury 1	1.9	1.7	1.9	3.1	2.9	3.1	3.8	3.5	3.8	3.5	3.2	3.5	7.2	6.7	7.2
Sprague	4.1	2.2	3.2	7.2	4.0	5.6	8.6	4.6	6.6	9.5	5.3	7.5	21.1	11.2	16.2
Ex situ mescosm study 2															
Balmoral	1.5	2.3	3.1	2.0	3.2	4.2	3.0	4.8	6.3	2.9	4.6	6.0	6.0	9.6	12.8
Dencross 1	7.7	15.0	20.2	9.1	17.3	23.2	16.8	35.3	50.7	14.9	26.9	34.6	35.0	73.4	105.6
Dencross 2	14.3	17.2	22.8	12.1	14.6	19.5	33.5	41.6	59.1	26.0	30.4	38.3	70.2	87.3	124.0
Denham	3.6	5.6	9.1	9.6	14.5	22.2	7.4	11.9	20.1	7.2	11.1	17.4	15.6	25.0	42.2
Fyala 2	0.6	1.0	1.3	1.0	1.7	2.1	1.2	2.1	2.6	1.1	2.0	2.5	2.3	4.1	5.1
Marquette	11.8	11.8	12.5	20.5	20.4	21.4	26.9	26.8	28.5	20.5	20.5	21.5	51.7	51.5	54.7
Osborne 2	2.4	3.7	4.8	2.4	3.8	4.9	4.8	7.6	10.1	4.6	7.1	9.2	9.7	15.4	20.3
Pembina	3.0	2.3	3.3	5.0	3.9	5.4	6.2	4.8	6.8	6.1	4.7	6.6	12.9	10.0	14.2
Red River 1	0.9	1.2	1.3	1.5	1.9	2.1	1.9	2.4	2.6	1.8	2.3	2.5	3.7	4.6	5.2
Red River 2	5.2	8.4	8.8	8.2	12.8	13.5	11.1	18.2	19.3	10.0	15.5	16.2	22.2	36.6	38.6
Red River 3	15.3	17.8	24.1	20.0	23.0	30.5	36.0	43.2	63.4	27.0	30.7	39.4	74.0	88.7	130.1
Scanterbury 2	5.4	5.4	7.5	7.4	7.4	10.2	11.4	11.4	16.2	10.5	10.6	14.3	23.5	23.6	33.4
Scanterbury 3	**In situ Mesocosm study**														
Control	0.8	1.1	1.4	1.5	1.9	2.5	1.7	2.2	2.8	1.5	2.0	2.5	3.1	4.0	5.2
Fertilized	1.5	2.4	3.0	2.6	4.0	5.0	3.1	4.8	6.2	2.9	4.3	5.5	5.9	9.1	11.7
Manured	1.1	2.0	2.6	2.1	3.8	4.8	2.2	4.1	5.2	2.0	3.7	4.7	4.0	7.6	9.8

Supplemental Table S3. Dissolved reactive phosphorus concentration (mg L^{-1}) in pore water with flooding time (Geometric LS Mean, n=4) in 24 soils from two *ex situ* mesocosm studies

	Time (Days after flooding)								
Soil series	**0**	**7**	**14**	**21**	**28**	**35**	**42**	**49**	**56**
				Ex situ mescosm study 1					
Almasippi	0.29F[†]	0.45EF	0.59DE	0.77CDE	0.88BCDE	1.08ABBCD	1.55ABC	1.86AB	2.21A
Arborg	0.50E	0.65DE	0.79DE	0.98CDE	1.24CD	1.85BC	2.74AB	3.68AB	4.86A
Fyala 1	0.50	0.58	0.67	0.59	0.55	0.57	0.80	0.90	1.16
Lakeland 1	0.20B	0.23B	0.27B	0.26B	0.42AB	0.44AB	0.29B	0.67A	0.79A
Lakeland 2	0.99B	1.34AB	1.56AB	1.56AB	1.88AB	1.98AB	2.33AB	2.58AB	2.86A
Long Plain	0.61C	0.83BC	0.97BC	1.02BC	1.00BC	1.26BC	2.00AB	2.64A	3.07A
Newdale	0.40B	0.48AB	0.49AB	0.50AB	0.61AB	0.75AB	0.93AB	1.02AB	1.19A
Niverville	0.90B	1.21AB	1.43AB	1.46AB	1.35AB	1.74AB	2.42A	2.74A	3.08A
Osborne	1.12C	1.14C	1.30C	1.41BC	1.64ABC	2.02ABC	2.78ABC	3.24AB	3.76A
Reinland	0.66E	0.99DE	1.21CDE	1.40BCDE	1.79ABCD	2.41ABC	2.99AB	3.16AB	3.48A
Scanterbury	0.15	0.14	0.16	0.18	0.20	0.20	0.19	0.18	0.20
Sprague	0.43C	0.63C	0.72BC	0.74C	1.43AB	1.81A	2.23A	2.46A	2.68A
				Ex situ mesocosm study 2					
Balmoral	0.19C	0.36ABC	0.24BC	0.19C	0.44ABC	0.82A	0.51ABC	0.87A	0.64AB
Dencross 1	1.07B	4.2A	4.35A	2.31AB	2.61AB	3.18AB	3.92A	2.99AB	5.07A
Dencross 2	4.81	6.16	6.04	4.12	4.92	6.70	6.08	6.67	6.64
Denham	0.71B	0.85B	0.74B	0.84B	0.76B	1.68AB	1.89AB	3.23A	4.16A
Fyala 2	0.09CD	0.19ABC	0.05D	0.12BCD	0.86A	0.56A	0.40AB	0.61A	0.49A
Marquette	2.82AB	4.09AB	4.72AB	3.02AB	1.76BC	2.42BC	8.38A	0.73C	2.26BC
Osborne 2	0.53AB	0.67AB	0.48AB	0.36B	0.64AB	1.24A	0.60AB	0.83AB	0.71AB
Pembina	0.28ABC	0.37ABC	0.12C	0.17BC	0.57AB	0.76A	0.51AB	0.38ABC	0.36ABC
Red River 1	0.18AB	0.28AB	0.17AB	0.36AB	0.30AB	0.53A	0.13B	0.25AB	0.14B
Red River 2	1.73	2.14	2.03	1.94	2.74	4.08	4.14	3.70	4.15
Red River 3	7.09B	10.81AB	10.24AB	6.96B	11.01AB	15.01A	15.54A	13.81A	11.04AB
Scanterbury 2	1.30D	2.05CD	1.74CD	2.28BCD	3.78ABCD	5.30ABC	5.21ABC	7.15AB	7.78A

[†] Within each row, means followed by the same upper case letter are not significantly different at $P > 0.05$

Supplemental Table S4. Dissolved reactive phosphorus concentration (mg L^{-1}) in floodwater with flooding time (Geometric LS Mean, n=4) in 24 soils from two *ex situ* mesocosm studies

	Time (Days after flooding)								
Soil Series	**0**	**7**	**14**	**21**	**28**	**35**	**42**	**49**	**56**
				Ex situ mescosm study 1					
Almasippi	0.10ABC[†]	0.15A	0.06ABC	0.03BC	0.11ABC	0.07ABC	0.12AB	0.03C	0.05ABC
Arborg	0.25B	0.54AB	0.51AB	0.85AB	0.91AB	1.04AB	0.82AB	1.28A	1.22A
Fyala	0.14ABC	0.29A	0.38A	0.32A	0.35A	0.23A	0.17AB	0.05C	0.05BC
Lakeland 1	0.12A	0.15A	0.11A	0.02A	0.06AB	0.02B	0.06AB	0.02B	0.04AB
Lakeland 2	0.26	0.57	0.63	0.57	0.51	0.36	0.49	0.37	0.37
Long Plain	0.10B	0.24AB	0.29AB	0.27AB	0.45A	0.47A	0.59A	0.27AB	0.32AB
Newdale	0.13AB	0.32AB	0.21AB	0.09B	0.31A	0.25AB	0.26AB	0.24AB	0.27AB
Niverville	0.24	0.54	0.72	0.59	0.86	0.87	0.70	0.49	0.52
Osborne	0.36ABC	0.55A	0.50A	0.13BC	0.47A	0.34ABC	0.38AB	0.11C	0.15ABC
Reinland	0.13B	0.34AB	0.51A	0.54A	0.85A	1.00A	1.21A	0.74A	1.00A
Scanterbury	0.11AB	0.14A	0.08ABC	0.03BC	0.05ABC	0.04ABC	0.02C	0.02C	0.04ABC
Sprague	0.12	0.25	0.15	0.07	0.12	0.08	0.18	0.11	0.13
				Ex situ mesocosm study 2					
Balmoral	0.08	0.17	0.22	0.005	0.29	0.13	0.24	0.12	0.06
Dencross 1	0.44C	2.21AB	2.81A	2.96A	2.90A	2.58AB	2.60AB	1.85B	1.75B
Dencross 2	0.54C	2.45B	3.10AB	3.39AB	3.78A	3.63A	4.15A	3.41AB	3.54AB
Denham	0.15B	0.54A	0.56A	0.13B	0.12B	0.22AB	0.29AB	0.10B	0.07B
Fyala 2	0.05	0.06	0.08	<0.005	0.15	0.04	0.11	0.02	<0.005
Marquette	0.50D	3.01AB	3.66A	3.59A	3.27A	2.91AB	3.02A	2.04BC	1.38C
Osborne 2	0.15AB	0.32AB	0.35A	0.14AB	0.18AB	0.20AB	0.28AB	0.10AB	0.02B
Pembina	0.13	0.23	0.17	0.002	0.01	0.11	0.06	<0.005	<0.005
Red River 1	0.09	0.15	0.24	0.06	0.12	0.27	0.23	0.06	0.03
Red River 2	0.38D	1.18ABC	1.41ABC	1.38ABC	1.52AB	1.57AB	1.73A	0.95BC	0.88C
Red River 3	1.00E	4.44CD	5.45ABCD	6.11ABC	6.74A	6.35AB	6.67A	4.64BCD	4.20D
Scanterbury 2	0.28F	0.92E	0.95DE	1.09CDE	1.57ABCD	1.90AB	2.23A	1.59ABC	1.30BCDE

[†] Within each row, means followed by the same uppercase letter are not significantly different at $P > 0.05$

Supplemental Table S5. Changes in dissolved reactive phosphorus concentrations (mg L^{-1}) in pore water and floodwater in unamended, fertilizer amended and manure amended plots with flooding time from the *in situ* mesocosm study (Geometric LS Means; n=4)

Days after flooding (DAF)	Pore water dissolved reactive P concentration (mg L^{-1}) †			Floodwater dissolved reactive P concentration (mg L^{-1})		
	Unamended	Fertilizer amended	Manure amended	Unamended	Fertilizer amended	Manure amended
1	0.07	0.31	0.24	0.05	0.12	0.12
5	0.08	0.23	0.22	0.08	0.16	0.21
7	0.05	0.29	0.18	0.03	0.12	0.12
11	0.05	0.23	0.19	0.05	0.13	0.12
14	0.04	0.23	0.19	0.06	0.19	0.15
19	0.05	0.25	0.12	0.08	0.16	0.12
22	0.06	0.22	0.07	0.08	0.16	0.11
25	0.06	0.23	0.11	0.07	0.19	0.10
28	0.06	0.22	0.08	0.07	0.16	0.11
32	0.06	0.26	0.08	0.07	0.15	0.15
34	0.06	0.28	0.10	0.08	0.15	0.09
39	0.03	0.21	0.05	0.06	0.14	0.08
42	0.06	0.23	0.10	0.07	0.15	0.09
Means across all DAF	0.05b ‡	0.23a	0.11ab	0.06b	0.15a	0.12ab

† For pore water and floodwater DRP concentrations, days after flooding or treatment × days after flooding interaction were not significant (P>= 0.05).

‡ Means across DAF with different treatments for pore water and floodwater followed by the same lowercase letter are not significantly different at P >0.05.