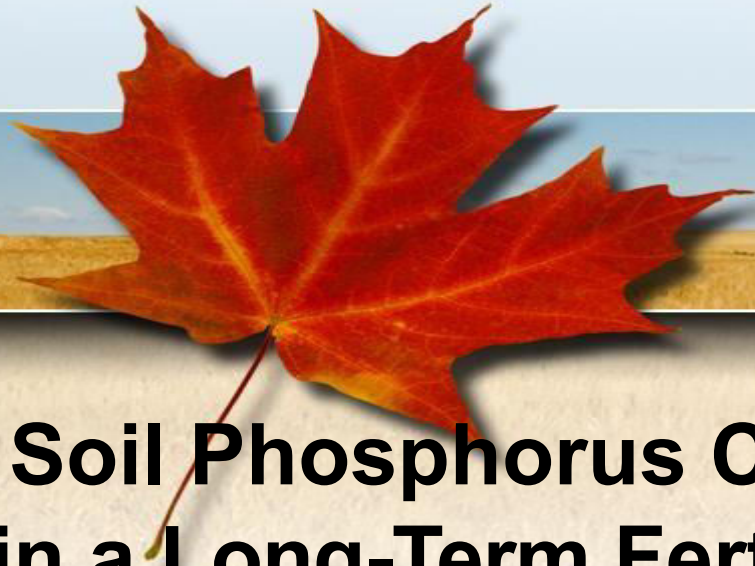




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# Soil Phosphorus Concentrations And Wheat Yields in a Long-Term Fertilization Study in Saskatchewan, Canada

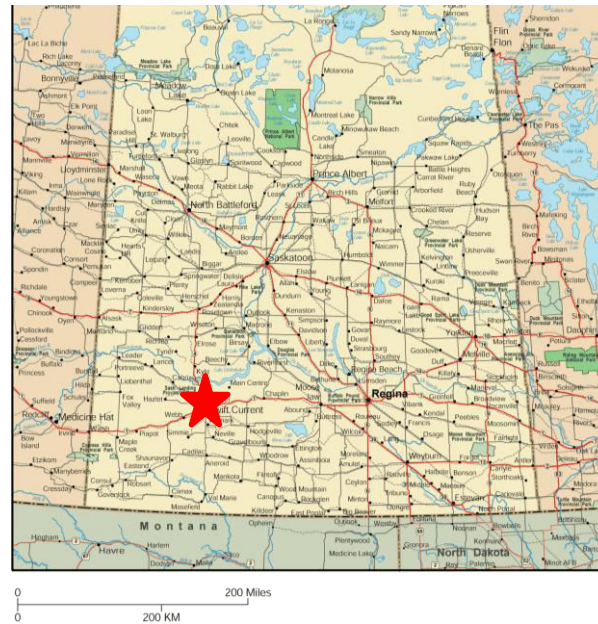
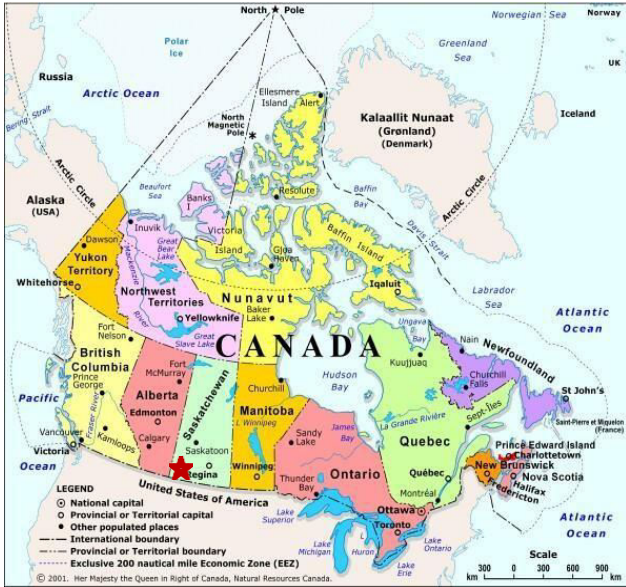
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# Study Sites

“Old Rotation” plots in Swift Current, SK, at the Agriculture & Agri-Food Canada Swift Current Research and Development Centre



- Northern Great Plains
- Dryland agriculture, wheat-based
- Semi-arid: 300-400 mm precipitation, 1/3 as snow

Soils: Orthic Brown Chernozems (Canadian Classification System); Aridic Haploborolls (USDA); Haplic Kastanozems (FAO)

# Research Plots

**Old Rotation plots:** established 1967 (lentil-wheat, 1982); 3 replicates; all phases present annually; combinations with N and P; N (32-50 kg ha<sup>-1</sup>): NH<sub>4</sub>NO<sub>3</sub> 1967-2008; urea from 2009; +P (10 kg ha<sup>-1</sup>), monoammonium phosphate (MAP); tilled; straw remains

**Continuous wheat (CW), fallow-wheat-wheat (FW), fallow-wheat (FW); lentil-wheat (LW)**

**CW:** 1967, +N+P, -N+P; 1995: +N+P, -N-P;

**FWW:** 1967, +N+P, -N+P, N only; 1995, +N+P, -N-P; no N, no P (None);

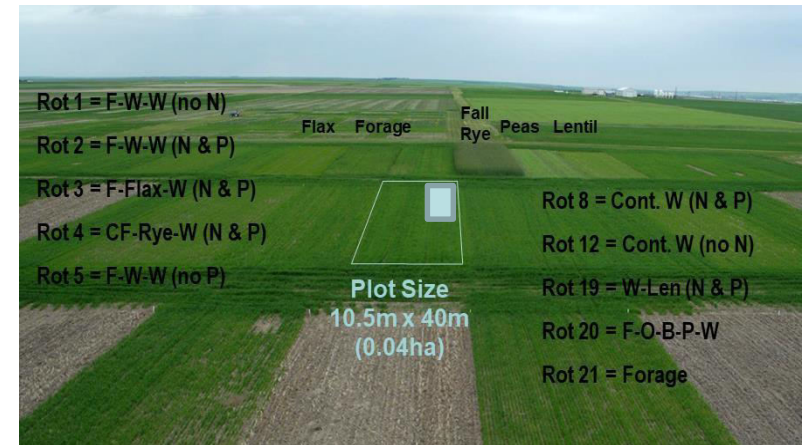
**FW:** 1967, +N+P; 2008, +N-P;

**LW:** 1982, +N+P (N wheat only, P both lentil and wheat); 2008, +N-P

**Sampling:** soil and plants each fall; soils archived from 1995 (0-7.5 and 7.5-15 cm depths)

**Plant Analysis:** grain yield, plant height, grain P and N, straw N and P;

**Soil Analysis:** total P, total organic P; bicarbonate P (and N); Mehlich P and cations; CaCl<sub>2</sub>; some years: P enzyme activity; resin P; P forms by NMR; microbial P; metagenomic analysis



# Results: Total and Olsen P Concentrations

Rotation	Treatment	Total P (kg ha <sup>-1</sup> )	Olsen P (kg ha <sup>-1</sup> )
FWW	+N+P	949 ± 8.3 a	27.6 ± 1.05 b
	+N-P	901 ± 7.0 b	16.5 ± 0.58 d
	-N+P	957 ± 8.4 a	34.7 ± 1.05 a
	-N-P	919 ± 6.7 bc	23.0 ± 0.65 c
None	N only	818 ± 7.4 cd	9.93 ± 0.45 e
	None	867 ± 6.5 d	9.80 ± 0.24 e
CW	+N+P	893 ± 12.2 z	25.4 ± 1.47 x
	+N-P	861 ± 9.15 z	14.8 ± 0.88 z
	-N+P	1002 ± 14.2 x	43.9 ± 2.07 w
	-N-P	954 ± 12.8 y	20.1 ± 1.01 y
FW	+N+P	997 ± 10.8 r	40.4 ± 1.63 r
	+N-P	965 ± 8.89 s	34.0 ± 1.17 s
LW	+N+P	521 ± 6.45 m	19.7 ± 0.93 m
	+N-P	494 ± 7.42 n	14.2 ± 0.60 n

0-15 cm depth; values are means (± std. error)

- Values are kg ha<sup>-1</sup> for 0-15 cm depth
- FWW and CW: 3-year averages, 1995-2015; FW and LW: 2-year averages, 2008-2016
- No significant treatment\* date interaction
- **Adding P but not N increases total P and Olsen P for all rotations**
- **Stopping P reduces total and Olsen P concentrations, especially in treatments with N**

# Results: Crop Yields and Grain P

Rotation	Treatment	Grain Yield (Mg ha <sup>-1</sup> )	Grain P (Mg ha <sup>-1</sup> )
FWW	+N+P	2.75 ± 0.09 a	11.4 ± 0.37 a
	+N-P	2.61 ± 0.08 a	10.2 ± 0.32 ab
	-N+P	2.17 ± 0.09 bc	9.37 ± 0.37 bc
	-N-P	2.02 ± 0.09 c	8.42 ± 0.34 cd
	N only	2.38 ± 0.09 ab	8.15 ± 0.27 cd
	None	1.98 ± 0.09 c	7.44 ± 0.24 d
CW	+N+P	2.44 ± 0.10 x	10.8 ± 0.41 x
	+N-P	2.08 ± 0.08 y	8.21 ± 0.37 y
	-N+P	1.58 ± 0.06 z	7.68 ± 0.30 y
	-N-P	1.45 ± 0.07 z	6.93 ± 0.36 y
FW	+N+P	3.33 ± 0.14	12.7 ± 0.69
	+N-P	3.04 ± 0.16	11.7 ± 0.76
LW	+N+P	3.51 ± 0.27	15.4 ± 1.22
	+N-P	3.24 ± 0.24	13.9 ± 1.11

Year	FWW Grain Yield (Mg ha <sup>-1</sup> )	CW Grain Yield (Mg ha <sup>-1</sup> )	FWW Grain P (Mg ha <sup>-1</sup> )	CW Grain P (Mg ha <sup>-1</sup> )	Precipitation (mm)	Mean Temperature (C)
1997	2.59 ± .07 ab	2.20 ± .12 x	8.91 ± .26 b	8.93 ± .46wxy	438 ± 52	3.14 ± .39 b
2000	2.27 ± .11 bc	1.76 ± .16 yz	9.24 ± .42 b	8.25 ± .63 yz	390 ± 22	4.32 ± .35 a
2003	2.00 ± .07 cd	1.63 ± .09 yz	7.61 ± .28 c	7.07 ± .36 yz	338 ± 87	4.39 ± .38 ab
2006	2.47 ± .08 ab	2.12 ± .11 xy	10.7 ± .31 a	10.6 ± .36 w	395 ± 16	4.89 ± .34 a
<b>2009</b>	<b>1.82 ± .06 d</b>	<b>1.33 ± .10 z</b>	<b>6.64 ± .19 c</b>	<b>2.76 ± 0.40 z</b>	<b>322 ± 55</b>	<b>4.05 ± .38 ab</b>
2012*	2.75 ± .10 a	2.24 ± .12 a	11.7 ± .40 a	10.2 ± .61 wx	501 ± 70	3.75 ± .37 ab
2015	2.36 ± .11 bc	1.91 ± .11 xy	9.32 ± .42 b	7.83 ± .53 y	396 ± 30	4.04 ± .38 ab

Year	FW Grain Yield (Mg ha <sup>-1</sup> )	LW ** Grain Yield (Mg ha <sup>-1</sup> )	FW Grain P (Mg ha <sup>-1</sup> )	LW ** Grain P (Mg ha <sup>-1</sup> )	Precipitation (mm)	Mean Temperature (C)
2010*	2.85 ± .22 ab	2.48 ± .39 y	10.9 ± 1.21 ab	11.4 ± 1.94 y	468 ± 171	3.67 ± .46 b
2012	3.59 ± .22 a	4.08 ± .31 x	14.5 ± 1.07 a	18.8 ± 1.51 x	432 ± 26	4.49 ± .45 ab
2014	3.46 ± .09 ab	4.08 ± .12 x	13.2 ± .54 ab	17.1 ± .40 x	416 ± 40	3.25 ± .45 b
2016	2.88 ± .23 b	2.87 ± .30 y	10.4 ± .79 b	11.3 ± 1.17 y	472 ± 116	5.69 ± .41 a

Stopping P significantly affected only CW +N, for 1995-2015 period. Yield and grain P more affected by N treatments and weather

\* 2010 one of wettest years on record

\*\* Wheat yields only

# Summary

- Fallow-wheat-wheat and continuous wheat, 1995-2015
  - Total and Olsen P decreased when P fertilizer stopped; increased when added without N
  - Olsen still detectable in FWW plots without P since 1967;
  - No P effects on yield except CW +N+P v. +N-P
- Fallow-wheat and lentil-wheat, 2008-2016
  - Total P and Olsen P declined in no-P sub-plots; no significant effects on yield
- All rotations
  - Yields more affected by N than P, and by annual precipitation
- **Note:** long-term N has altered pH (CW-N-P: 7.1; CW+N+P: 5.5), which has significantly affected exchangeable Ca, Mg, Fe, Al, P enzyme activities and the soil microbial community



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# Thank you!

For more information, please contact:  
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## Related Publications:

- Selles et al. 2011 Can. J. Soil Sci. 91: 39-52
- Liu et al. 2015 Environ Sci. Technol. 49:168-176
- Li et al. 2020 Environ. Microbiol. 22:1066-1088.
- Chen et al. 2021 Geoderma 404:115274

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