Impact of fertilizer P source, rate, and placement strategy on yield, nutrient uptake, and P losses in snowmelt runoff water across variable topographies in Saskatchewan

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INTRODUCTION

- The plant availability and mobility in soil of a fertilizer phosphorus (P) source is influenced by the solubility of the fertilizer product and the reaction products formed in soil over time.
- Few studies have compared agronomic and environmental performance of existing and new fertilizer P sources under Canadian Prairie Conditions.
- Consideration of landscape and soil properties may benefit the site-specific prescription of 4R Nutrient Stewardship practices.

OBJECTIVES

A three-year field study was initiated in spring of 2021 at two sites with unique landform complex positions (upslope and lowslope) and soil properties. Agronomic (canola yield, P and N uptake) and environmental (soluble inorganic P losses in runoff water) performance was evaluated across fertilizer P source, rate, and placement strategy treatments.

METHODS

- **Experimental design**

RCBD Design. Crop rotation: 2021 wheat - 2022 pea – 2023 canola. Poster covers 2023 season.

- **Sites**
  - -Central Butte (CB) Upslope and Lowslope.
  - -Shared management history at both sites.
- **Treatments since 2021**
  - -Source: 8 P sources and control (0 P)
  - -Rate: 20 (Low) vs 40 (High) kg P_2O_5 ha^{-1}
  - -Placement: Side-band vs surface broadcast
  - -All treatments received basal N, K, S, micros
- **Seeding**
  - -2023 Crop: Canola (var PV681)
  - -Seeder: 1m-wide with 25.4 cm shank spacing
  - -Side-band P: Below and to side of seed-row
  - -Broadcast P: Immediately prior to seeding.
- **Harvest**
  - -Two 1m length rows harvested from each plot to determine grain and straw yield.
  - -P and N uptake in straw determined by acid digest and automated colorimetry.

RESULTS

Table 1. List of fertilizer P sources by name and chemical analysis used in study.

	Fertilizer P Name	Chemical Analysis (%N - $\%P_2O_5$ - $\%K_2O$ - %S)
1	Control (C)	0-0-0-0
2	Ammonium Phosphate Sulfate (APS)	17-20-0-15
3	Liquid Ammonium Polyphosphate (LAP)	10-34-0-0
4	Monoammonium Phosphate (MAP)	11-52-0-0
5	Polymer Coated MAP (MAPC)	11-52-0-0
6	MAP + Elemental Sulfur (MAP+ES)	9-43-0-16
7	Rock Phosphate (RP)	0-3-0-0
8	Struvite (S)	5-28-0-0
9	Triple Super Phosphate (TSP)	0-45-0-0

Table 2. Fall 2022 Residual soil test P by site and experimental factor (0-15 cm).

Factor	Treatment	CB Upslope Modified Kelowna P (µg g^{-1})	CB Lowslope Modified Kelowna P (µg g^{-1})	CB Upslope A.E Resin P (µg 10 cm^{-2})	CB Lowslope A.E Resin P (µg 10 cm^{-2})
Source	C	9.7c[1]	13.3	2.6c	4.8
	APS	17.9a	19.3	5.4abc	6.5
	LAP	13.5abc	18.4	4.3abc	7.0
	MAP	20.7a	16.0	6.3ab	6.3
	MAPC	17.7ab	19.3	8.1a	7.0
	MAP+ES	22.0a	18.4	8.2a	5.4
	RP	10.2bc	14.4	2.8bc	5.1
	S	19.0a	18.4	6.1a	7.2
	TSP	19.4a	16.8	7.4a	5.5
	P Value	0.01	0.22	<0.01	0.69
Rate	20 kg P_2O_5 ha^{-1}	14.6	15.8	4.3	5.7
	40 kg P_2O_5 ha^{-1}	18.8	18.4	7.1	6.4
	P Value	0.18	0.78	0.73	0.11
Placement	Side-band	15.4	16.9	5.1	6.1
	Broadcast	18.0	17.4	6.3	6.1
	P Value	0.47	0.50	0.80	0.81

[1]Within a column and factor, means followed by a different letter are significantly different from each other (p≤0.05) using Tukey's HSD.

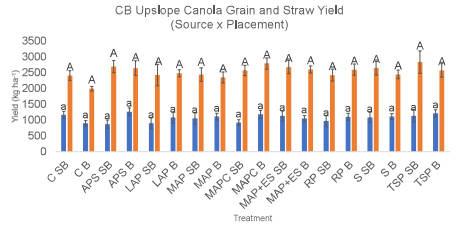

Figure 1. Mean (n=8) canola grain and straw yield at CB Upslope site by fertilizer source by placement interaction. Error bars are one standard error. Means with a different letter are significantly different from each other (p≤0.05) using Tukey's HSD.

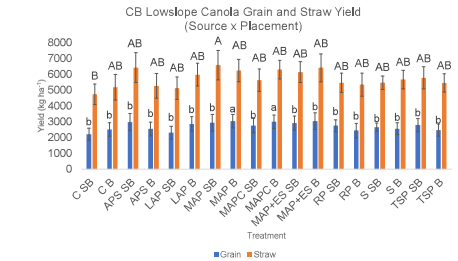

Figure 2. Mean (n=8) canola grain and straw yield at CB Lowslope site by fertilizer source by placement interaction. Error bars are one standard error. Means with a different letter are significantly different from each other (p≤0.05) using Tukey's HSD.

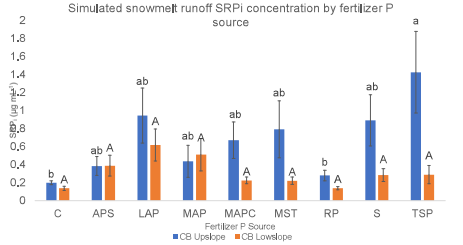

Figure 3. Mean (n=8) SRP, concentration in simulated snowmelt runoff water by fertilizer source conducted on intact surface soil slabs removed in fall of 2021 from the two field sites. Error bars represent the standard error of the mean of each treatment. For a site, bars followed by different letters indicate a significant (p<0.10) difference using Tukey's HSD.

Table 3. 2022 Mean total (grain + straw) uptake by site and source by rate interaction.

Factor	Source	Rate	CB Upslope Total P Uptake (kg P ha^{-1})	CB Lowslope Total P Uptake (kg P ha^{-1})
	C	0 kg P_2O_5 ha^{-1}	8.7abcd[1]	13.2
	APS	20 kg P_2O_5 ha^{-1}	9.3abcd	13.4
	LAP	20 kg P_2O_5 ha^{-1}	8.4bcd	15.0
	MAP	20 kg P_2O_5 ha^{-1}	8.9abcd	13.5
	MAPC	20 kg P_2O_5 ha^{-1}	7.6d	15.1
	MAP+ES	20 kg P_2O_5 ha^{-1}	9.5abcd	14.7
	RP	20 kg P_2O_5 ha^{-1}	7.6cd	12.7
Source x Rate	S	20 kg P_2O_5 ha^{-1}	8.7abcd	13.4
	TSP	20 kg P_2O_5 ha^{-1}	9.3abcd	13.8
	C	0 kg P_2O_5 ha^{-1}	8.4bcd	13.7
	APS	40 kg P_2O_5 ha^{-1}	11.2a	17.0
	LAP	40 kg P_2O_5 ha^{-1}	8.4bcd	16.2
	MAP	40 kg P_2O_5 ha^{-1}	10.4ab	13.8
	MAPC	40 kg P_2O_5 ha^{-1}	10.5ab	15.8
	MAP+ES	40 kg P_2O_5 ha^{-1}	11.1a	14.4
	RP	40 kg P_2O_5 ha^{-1}	7.5d	14.4
	S	40 kg P_2O_5 ha^{-1}	9.6abcd	14.0
	TSP	40 kg P_2O_5 ha^{-1}	10.2abc	14.0
		P Value	0.02	0.89

[1]Within a column, means followed by a different letter are significantly different from each other (p≤0.05) using Tukey's HSD.

Figure 4. Photo of CB Upslope site during harvest in fall of 2021.

DISCUSSION

- Fall 2022 soil extractable and resin exchangeable P was significantly influenced by fertilizer P source applied in previous 2 yrs at CB Upslope site. The MAP sources had highest residual P.
- The 2023 canola yield was significantly impacted by fertilizer P source x placement interaction at CB Lowslope site (p<0.05). At CB Upslope site, grain and straw yield was not significantly influenced by fertilizer source, rate, or placement. This is explained by dry conditions in 2023 and previous work showing inconsistent canola yield response to P application on soils with greater than ~15 ppm Olsen P (Karamanos, 2007).
- The canola total P uptake (grain+ straw) was significantly influenced by fertilizer source x rate interaction at the CB Upslope site, with the greatest uptake observed from sulfur-containing P fertilizers at the 40 kg P_2O_5 ha^{-1} rate. Previously, Ahmed et al (2017) observed improved plant P uptake from combined applications of MAP with S fertilizer. Crop P uptake and removal was greater at Low slope site where moisture conditions were more favorable.
- The SRP_i concentrations in snowmelt water were influenced by source at CB Upslope site but not the Lowslope site. Concentrations were highest with triple superphosphate and lowest with the low solubility rock phosphate. Averaged across sources, SRP_i concentration in runoff water from the CB Upslope plots was greater than the CB Lowslope site (p<0.05) and agrees with crop removal, soil properties and landscape position as important factors in nutrient transport (Crossman et al., 2014).

REFERENCES

Ahmed, H.P. J.J. Schoenau, T. King, and G. Kar. (2017). Effects of seed-placed sulfur fertilizers on canola, wheat, and pea yield; sulfur uptake; and soil sulfate concentrations over time in three prairie soils. *J. Plant. Nutr.* https://doi.org/10.1080/01904167.2016.1262413

Crossman, J., M.N. Futter, P.G. Whitehead, E. Stainsby, H.M. Baulch, L. Jin, S.K. Oni, R.L. Wilby, and P.J. Dillon. (2014). Flow pathways and nutrient transport mechanisms drive hydrochemical sensitivity to climate change across catchments with different geology and topography. *Hydrol. Earth Syst. Sci.*, https://doi.org/10.5194/hess-18-5125-2014

Karamanos, R. (2007). Agroeconomics of phosphate fertilizer in Manitoba. In: Proceedings of the 8th Annual Manitoba Agronomists Conference. 11-12 Dec. 2007. University of Manitoba, Winnipeg, MB, Canada.

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