# Phosphorus export as influenced by placement method in two contrasting sites in south-central Saskatchewan

J.T. Wiens, B. Weiseth, B.J. Cade-Menun, J.J. Schoenau

# P Placement

- Most P placed in-soil
  - Plant access
  - Low quantities
- Broadcast considered for higher rates of P application
  - Speed of application
  - Replenish soil P after large crop
- Want to maximize crop P uptake and minimize off-site export in water, limit environmental effect

# P Runoff

- Concern of P runoff due to eutrophication
- P loss usually agronomically negligible (< 1 kg P / ha)
  - Load from watershed can create concern for concentrations in surface waters
- Research conducted primarily on manure, little information on inorganic amendments
  - What research has been done in other jurisdictions suggests in-soil P placement is better in reducing P export in water.

# Experimental Design

Combination of 2 M.Sc. Projects : Blake Weiseth , Jordan Wiens

2 field sites at Central Butte

- **CT**- 2014, soybean (Weiseth study)
  - No P fertilizer added, low P levels
  - Conventional tillage past 25 years, wheat-tillage fallow
- **NT**-2015-16, wheat (’15) canola (’16) (Wiens study)
  - P fertilizer added to recommended rates (~20 kg $P_2O_5$ $ha^{-1}$ $y^{-1}$), moderate P levels
  - No-till, pea-wheat-canola continuous crop

# Experimental Design

- RCBD
  - 4 replicates at each site
  - 4 placement strategies
    - seed placed — 20 kg $P_2O_5$ $ha^{-1}$
    - deep banded — 20 kg $P_2O_5$ $ha^{-1}$
    - broadcast with incorporation — 20 kg $P_2O_5$ $ha^{-1}$
    - broadcast at 3 rates: — 20, 40, 80 kg $P_2O_5$ $ha^{-1}$

# Experimental Design

Data collection

- Yield and crop P uptake
- Post-harvest extractable P
- Simulated snowmelt
  - Fractionated into P pools in 2016, not replicated, analyzed with NMR
  - Replicated in 2014

# Results

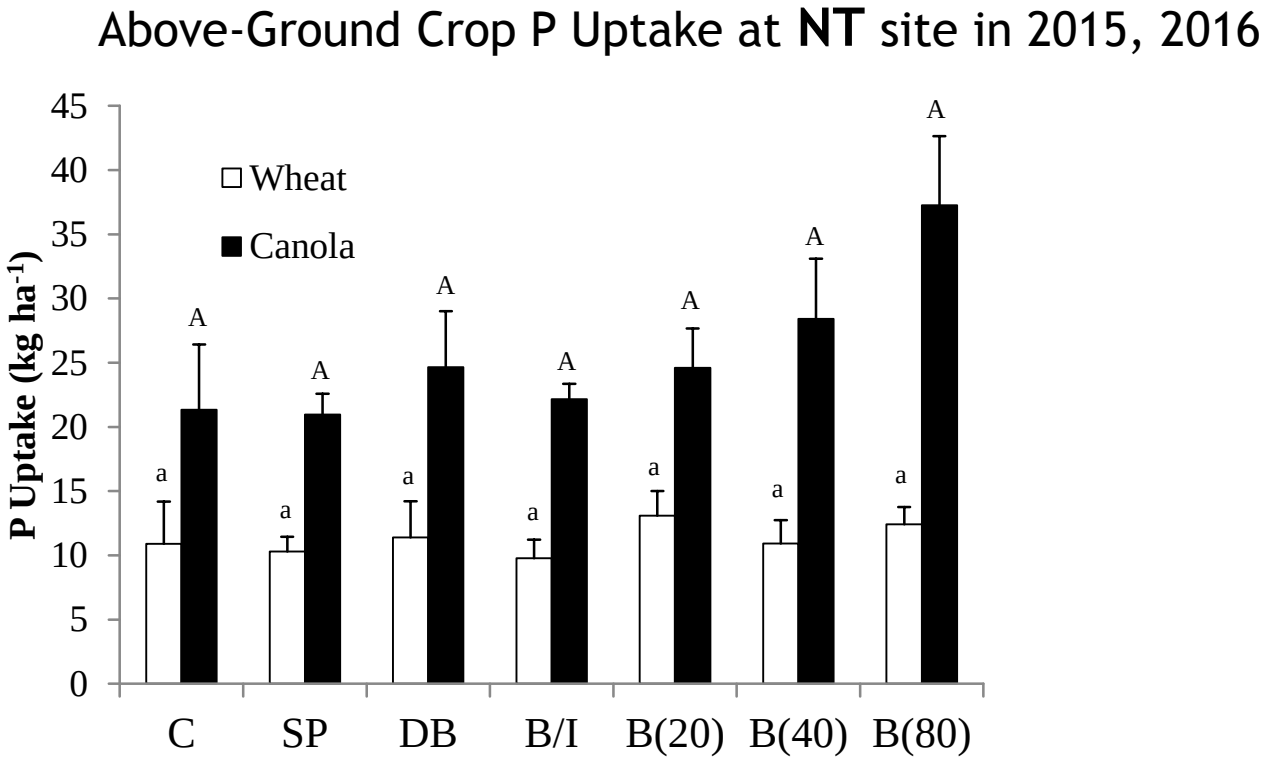


**Figure 1:** Mean (n=4) above ground P uptake at NT site for wheat (2015) and canola (2016). P treatments: C: Control (no P); SP: Seed-placed (20 kg $P_2O_5$ $ha^{-1}$); DB: Deep band (20 kg $P_2O_5$ $ha^{-1}$); B/I: Broadcast with incorporation (20 kg $P_2O_5$ $ha^{-1}$); B(20): Broadcast (20 kg $P_2O_5$ $ha^{-1}$); B(40): Broadcast (40 kg $P_2O_5$ $ha^{-1}$); and B(80): Broadcast (80 kg $P_2O_5$ $ha^{-1}$). For each crop, column means with the same letter are significantly different ($p<0.05$) using Tukey's HSD.

# Results

Dissolved Inorganic P in Simulated Snowmelt Runoff at CT (‘14) and NT (‘15,’16) Sites

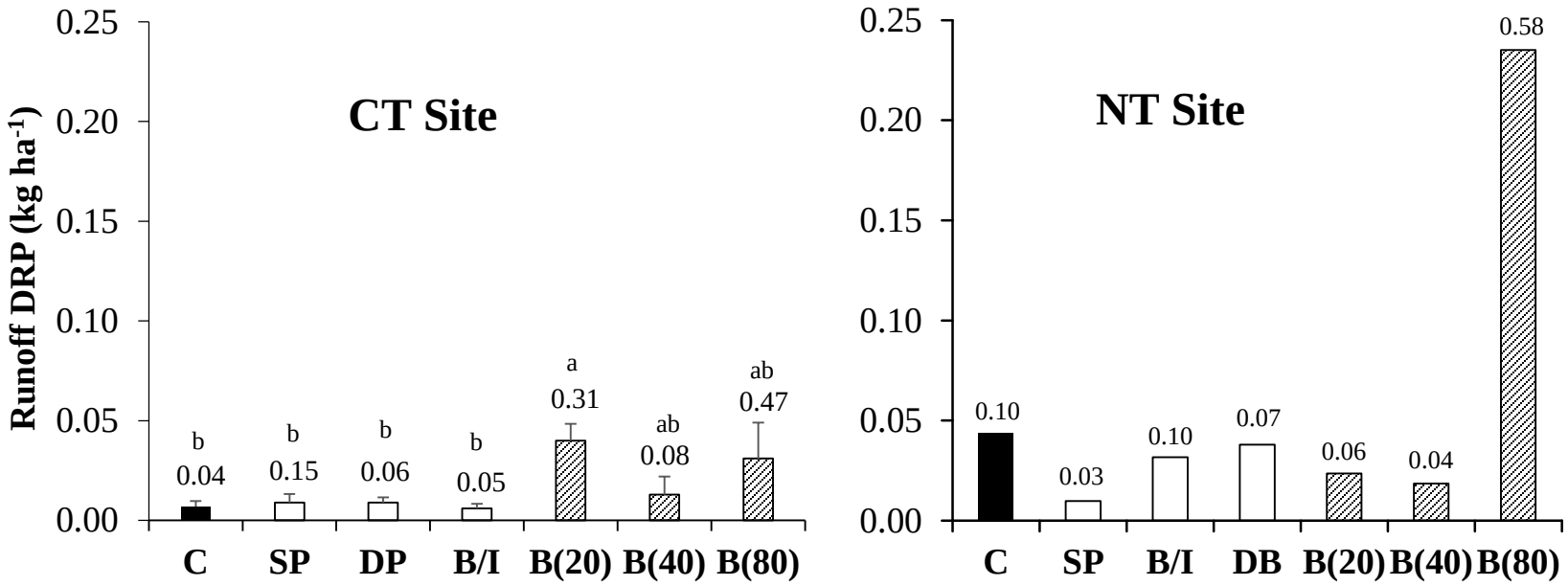


**Fig. 2**. Mean (n=4) dissolved molybdate-reactive phosphorus (DMRP) export as a function of fertilizer P application method and rate in a simulated snowmelt runoff experiment. The value above each bar represents mean concentration in the runoff (mg $L^{-1}$) of dissolved $P_i$ in the runoff water collected. Error bars represent the standard error of the mean. Means with different letters are significantly different (Tukey’s HSD, $p<0.05$)

# Results

**Table 1: Distribution of P among forms in snowmelt runoff water from the NT site as determined by quantitative $^{31}$P NMR.** The upper portion of the table shows percentage composition while the lower portion of the table provides the concentration of the compound category in the runoff.

| Treatment† | Fraction | $P_i$ | $P_o$ | Polyphosphate | IHP | Monoester | Diester | M:D | C Monoester‡ | C Diester | Deg | cM:D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | ----------%---------- | | | | | | | | |
| **Control** | Dissolved | 85.0 | 15.0 | 3.0 | 4.0 | 12.0 | 1.5 | 8.0 | 8.7 | 4.8 | 3.3 | 1.8 |
| | Particulate | 46.5 | 53.5 | 10.6 | 7.2 | 44.3 | 7.1 | 6.2 | 18.9 | 32.5 | 25.4 | 0.6 |
| **SP** | Particulate | 45.2 | 54.8 | 11.8 | 4.6 | 40.2 | 13.9 | 2.9 | 14.1 | 40.0 | 26.1 | 0.4 |
| **B(80)** | Particulate | 52.8 | 47.2 | 8.4 | 5.4 | 33.9 | 12.6 | 2.7 | 13.9 | 32.6 | 20.0 | 0.4 |
| **Treatment** | Fraction | $P_i$ | $P_o$ | Polyphosphate | IHP | Monoester | Diester | M:D | C Monoester | C Diester | Deg | cM:D |
| | | | | ----------mg P $L^{-1}$---------- | | | | | | | | |
| **Control** | Dissolved | 0.170 | 0.030 | 0.006 | 0.008 | 0.024 | 0.003 | 8.0 | 0.017 | 0.010 | 0.007 | 1.8 |
| | Particulate | 0.093 | 0.107 | 0.021 | 0.014 | 0.089 | 0.014 | 6.2 | 0.038 | 0.065 | 0.051 | 0.6 |
| **SP** | Particulate | 0.054 | 0.066 | 0.014 | 0.006 | 0.048 | 0.017 | 2.9 | 0.017 | 0.048 | 0.031 | 0.4 |
| **B(80)** | Particulate | 0.164 | 0.146 | 0.026 | 0.017 | 0.105 | 0.039 | 2.7 | 0.043 | 0.101 | 0.062 | 0.4 |

† **Control=no added P, SP=seed placed at 20 kg $P_2O_5$ $ha^{-1}$, B(80)=broadcast at 80 kg $P_2O_5$ $ha^{-1}$**

‡ **Corrected mono- and diesters, as well as the degradation coefficient and corrected mono- to diester ratio.**

# Discussion

- In-soil placement better than broadcasting in reducing P export in snowmelt runoff
- No yield response to P placement at NT site
  - Yield response at CT site
  - High crop P uptake, removal helps to address surface P loading issues from broadcasting
- Changes in form of P may be influenced by application method
  - High rate of broadcast P had higher proportion of P in dissolved reactive form
  - Increase in P of microbial origin at high application rates due to immobilization

# Conclusion

- In-soil P placement preferred
  - Agronomic benefit when soil P fertility is low
  - Reduces potential for export in runoff water
  - No difference between types of in-soil placement
- Broadcast application may be used to supply increased P, but rate of application should be limited, matched to crop removal to avoid surface loading and export

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