P MANAGEMENT FOR SOYBEANS: WHAT DID WE LEARN?

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Soybean acreage in Manitoba has increased dramatically during the last decade, bringing along many questions about nutrient management, including phosphorus (P), in soybean cropping systems. In response to these questions, a collaborative study was conducted over 28 site-years, from 2013 to 2015, to assess soybean yield response to P fertilizer and the risk of reduced plant stand and seed yield due to seed-placed fertilizer.

Treatments included different P fertilizer rates (20, 40 and 80 lb P_2O_5/ac) applied in side band, seed-placed or broadcast, plus a control which did not receive P fertilizer. Sites varied in soil texture and seeding equipment, which are important factors that can affect the risk of fertilizer toxicity. Also, 50% of the sites had soil P test in the very low – low range of sufficiency (0–10 ppm Olsen P), in which many crops would have high probability of response to P fertilizer (Table 1).

Four weeks after planting, plant stands were reduced by seed placed P at six of 28 site-years, but usually only at a rate of 80 lb P_2O_5/ac (Table 2). Seed placed P at rates of 20 and 40 lb P_2O_5/ac reduced emergence at one and two site-years, respectively. At maturity, seed yield was decreased in only two site-years. In both cases, fertilizer had been applied at 80 lb P_2O_5/ac seed placed and the plant stand was reduced below 100,000 plants per acre (replant threshold). Seed yield was not increased by the fertilizer applied at any site in any year, regardless of rate, placement or soil test P (Table 3).

Soybeans have a great ability to take up P from the soil, even at very low levels of soil test P. Control plots in sites with soil P levels as low as 3 ppm Olsen P yielded up to 60 bu/ac and did not yield less than the P fertilized treatments. Furthermore, there was no early or mid-season response to starter fertilizer (eg. 20 lb P_2O_5/ac in the seed row).

Complementary to the study on P rates and placements, another project looking at the soybean yield response to soil P instead of P fertilizer was conducted over seven site-years. Results reinforced the findings of the previous study, with no yield increase to higher soil test P or starter fertilizer spring applied as side band.

Considering the findings of this study, the recommendation for the maximum safe rate of P_2O_5 applied in the seed row according to the *Manitoba*

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Table 1. Site characterization according to soil test P, soil texture and equipment features.

Site	Olsen P (ppm)			Soil Texture	Row Spacing	Seeder Opener
–	2013	2014	2015	–	Inches	Type
Roseisle	N/A	4 (VL)	4 (VL)	Sandy Loam	8	Knife
Melita	3 (VL)	5 (L)	7 (L)	Sandy Loam	9.5	Knife
Brandon	5 (L)	6 (L)	5 (L)	Clay Loam	8	Knife
Carman	N/A	15 (H)	7 (L)	Sandy Clay Loam	8	Knife
Roblin	7 (L)	22 (VH)	8 (L)	Clay Loam	9	Knife
Beausejour	8 (L)	13 (M)	7 (L)	Heavy Clay	9	Disc
Arborg	14 (M)	22 (VH)	14 (M)	Silty Clay	9	Disc
St Adolphe	23 (VH)	25 (VH)	71 (VH)	Heavy Clay	7.3	Knife
Portage	34 (VH)	18 (H)	10 (L)	Clay Loam	12	Disc
Carberry	44 (VH)	11 (M)	15 (H)	Clay Loam	12	Disc

Note: VL = very low, L = low, M = Medium, H = High, VH = Very High

Table 2. Frequency and intensity of plant stand reduction caused by fertilizer toxicity.

	2013	2014	2015
# Sites	8	10	10
Range of plant stand of control ('000 plants/ac)	83–261	116–258	70–302
# Sites with plant stand reduction @ 20 lb SP	0	1[a]	0
# Sites with plant stand reduction @ 40 lb SP	0	2[a,d]	1[b]
# Sites with plant stand reduction @ 80 lb SP	2[c]	2[a,d]	1[c]
% Stand reduction	39–71	39–52	40

[a] At Portage in 2014, seed row placement of P fertilizer reduced seedling emergence for all rates of P, compared to the control, at 5% level of probability.

[b] At Roseisle in 2015, seed row placement of P fertilizer reduced seedling emergence at a rate of 40 lb P_2O_5 per acre, but not at 80 lb per acre. Therefore, this reduced emergence may have been random error.

[c] At Melita and Carberry in 2013, and Roblin in 2015 seedling emergence was reduced only by seed row P fertilizer applied at a rate of 80 lb P_2O_5 per acre.

[d] At Carberry in 2014, seedling emergence was reduced by seed-placed fertilizer at 40 and 80 lb P_2O_5 per acre.

Table 3. Soybean seed yield response to P fertilizer.

	2013	2014	2015
# Sites	8	10	10
Mean yearly seed yield (bu/ac)	46	42	51
Seed yield for control (bu/ac)	23–66	18–60	37–65
# Sites with yield increase with P fertilizer	0	0	0
# Sites with yield decrease with P fertilizer	2*	0	0
% Yield decrease*	29–36	0	0

* At Melita and Carberry in 2013, only the 80 lb P_2O_5/ac seed-placed treatment reduced seed yields compared to the control, at 5% level of probability.

Soil Fertility Guide (10 lb P_2O_5/ac) probably underestimates the soybean's tolerance to seed-placed fertilizer in most situations. However, it is difficult to define a new value for the maximum safe rate since there are many factors that can increase the risk of fertilizer toxicity and should be considered when determining the rate of P applied in the seed row, such as:

- Soil moisture (drier soils can increase the risk)
- Soil texture (medium to coarse soils have lower water holding capacity)
- Seeder opener type (disc openers spread fertilizer and seed less than knife or shovel openers, increasing the fertilizer concentration close to the seeds)
- Row spacing (wide spacings between seed row increase the fertilizer concentration in each seed row)
- Fertilizer rate (higher rates are more risky)

Over the long term, P fertilizer or manure must be applied to replace what is being removed by the crop based on historic yields. If applying the fertilizer in the soybean year of the rotation, the best placement would be side banding since it minimizes the risk of fertilizer toxicity and applies the fertilizer concentrated close to the root zone and below the soil surface, preventing losses through soil erosion and run off.

Since there were no positive responses to P fertilizer in this study, another option for maintaining P fertility would be to apply larger than usual rates of P to other crops in the crop rotation, in a strategy called *rotational fertilization*. For instance, when banding fertilizer for cereals, apply extra fertilizer to account for the P removed by soybeans in other years. This strategy also enables non-legume crops to make the most use of the N that comes with most P fertilizers.

Another option is to fall band P fertilizer prior to a cereal crop or canola in the rotation, by attaching an air cart or fertilizer tank to a cultivator, and applying fertilizer during the fall or spring tillage operation. Banding the P under the soil surface is the best placement for maximizing crop uptake and reducing the risk of runoff losses.

We strongly recommend the use of the P balance worksheet posted on the MPSG website in order to check the P balance in your specific crop rotation (link below). This will indicate whether there is a surplus or a deficit of P in your rotation. That worksheet, along with a more detailed factsheet on P fertilization strategies for Manitoba cropping systems can be found at www.manitobapulse.ca/production-resources/phosphorus-fertilization-strategies/. ■

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Arborg Seeder – Disc Opener

Brandon Seeder – Knife Opener