

4R PHOSPHORUS MANAGEMENT FOR SOYBEANS IN THE NORTHERN FRONTIER: RATE AND PLACEMENT EFFECTS ON PLANT STAND, BIOMASS AND SEED YIELD

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Abstract

Very little research has been conducted to determine the best rate, source, placement, and timing of P fertilizer for modern soybean cultivars grown in the Canadian Prairies. Preliminary results of the two years of field studies at 10 locations in Manitoba showed that typical agronomic rates of seed row P did not decrease plant stand and seed yield at any sites; nor was seed yield increased at any site, even with Olsen P concentrations as low as 3 ppm.

Introduction

Soybeans areas are expanding northerly across the Great Plains region of North America. Over the last 15 years in Manitoba, Canada, soybean acreage has increased from 18,000 acres in 1998 to over 1.3 million acres in 2014 (Statistics Canada, 2014). This increase in soybean acreage is due to a variety of factors, including the development of new varieties that are adapted to Manitoba's relatively short (95-135 frost-free days) and cool (2100-2500 crop heat units) growing season. Although Manitoba's soybean producers are proficient at inoculating their soybeans for maximum biological fixation of N, they have many questions about P fertilization and placement under Manitoba conditions. Most Prairie Canadian crops such as wheat, barley and canola respond more to banded (seed placed and side banded) P fertilizer than to broadcast applications. However, seed placed P is known to cause stand injury with some crops, including soybeans, at high rates of application.

Very little research has been conducted on P fertilization of soybeans in the Canadian Prairies and the results of that limited amount of research are inconsistent. As a result, little is known about the right source, right rate, right placement and right timing (4Rs) for P fertilization of modern soybean cultivars in this environment. For example, in field and growth chamber studies with Manitoba soils testing 2-5 ppm Olsen P, Bullen et al. (1983) measured very large soybean dry matter and seed yield responses to P fertilizer, especially when the P fertilizer was banded underneath the seed row. However, in unpublished field studies conducted in 2005 and 2006 near Brandon, Manitoba, soybean dry matter and seed yield were not increased by P fertilization, regardless of fertilizer source or placement method (C. Grant, pers. communication). In both of these previous sets of studies, the seed yields of soybeans were much smaller than those typically harvested from current cultivars. Moreover, many areas of soybean production are depleting soil P reserves, because there is a large amount of P removed by the crop and a relatively small amount of P fertilizer being applied.

As a result of these questions, the following study was initiated in 2013 to assess soybean response to rates and placements of P fertilizer, using a contemporary cultivar in a Manitoba environment. Preliminary results from the first and second year of the study are presented as follows.

Materials and Methods

Field studies were conducted at 10 locations across southern Manitoba; Olsen extractable P concentrations at these sites varied between 3 and 44 ppm. Seeding equipment varied by site, with row spacings between 7 and 12"; openers were disk, knife or hoe and 7 sites had side-band capability. Soybeans (Dekalb 24-10RY) were planted for a target stand of 210,000 plants/acre. All sites were planted between May 22 and June 3 in 2013 and between May 24 and June 9 in 2014. P fertilizer was applied as monoammonium phosphate (11-52-0). At 7 of 10 sites, 20, 40 and 80 lb P₂O₅/ac was applied in the seed row, as a sideband within 2" inches of the seed or surface broadcast prior to seeding and incorporated with seeding operations. At 3 of 10 sites, equipment limitations restricted treatments to seed placed and broadcast placements only. Treatments were replicated either 3 or 4 times. Plant stands were assessed at 4 weeks after planting and, at 7 of 10 sites, biomass was harvested and analyzed for P uptake at R3 stage. Stand and yield data were measured at all sites and analyzed using ANOVA using SAS Proc Mixed.

Results and Discussion

Overall growing conditions in Manitoba in 2013 were better than the average for most crops, so soybean yields at most sites were greater than the 10-year provincial average yield of 28 bu/ac (Table 3a, 3b). Seedrow placement of typical agronomic rates of fertilizer P (20 or 40 lb P₂O₅ per acre) did not affect soybean plant stands, biomass or seed yields at any site (Tables 1-3). However, an extremely high rate of seed row P (80 lb P₂O₅ per acre) decreased plant stand and seed yield at Melita and Carberry, which are located on coarse and medium-textured soils, respectively. None of the fertilizer P rates or placements increased soybean seed or biomass yield, even at the sites with less than 10 ppm Olsen extractable P.

In 2014, seedling stands at Portage and Carberry were reduced by seed-placed P applied at rates of 40 or 80 lb P₂O₅/ac (Tables 4a and 4b). At both of these locations, the row spacing was 12", an important factor for increasing the fertilizer salt concentration in the seed row. Large amounts of precipitation occurred at several sites shortly after planting, reducing the risk of seedling toxicity where it might otherwise have been expected. Biomass was not affected by the fertilizer rates and placement in 2014 (Table 5).

Conclusions

The lack of seed yield response to P and the high tolerance of soybeans to seedrow placed P was surprising. Although these results are from a diverse range of field sites, seed yield has been analyzed for only one field season so far. Therefore, as the study continues, we look forward to learning more about P fertilization for sustainable soybean production systems in Manitoba.

Table 1a. 2013 Stand Counts (thousand plants/acre)

Treatment	Brandon	Melita	Carberry	Beausejour	Arborg
Control	179 a	250 a	97 a	165 a	186 a
20 SP	172 a	160 a	110 a	170 a	174 a
20 SB	199 a	172 ab	109 a	186 a	180 a
20 BR	169 a	214 ab	112 a	190 a	201 a
40 SP	187 a	163 a	90 ab	180 a	171 a
40 SB	167 a	155 ab	93 ab	168 a	168 a
40 BR	189 a	183 ab	100 a	141 a	162 a
80 SP	189 a	73 b	60 b	178 a	142 a
80 SB	192 a	177 ab	96 a	167 a	201 a
80 BR	177 a	245 a	95 a	197 a	192 a

For each site, means followed by the same letter are not significantly different ($p=0.05$). SP = seed placed P fertilizer; SB = side-banded P fertilizer; BR = broadcast P fertilizer.

Table 1b. 2013 Stand Counts (thousand plants/acre)

Treatment	Roblin	Portage	St Adolphe
Control	263 a	111 a	84 a
20 SP	253 a	107 a	74 a
20 BR	233 a	123 a	67 a
40 SP	202 a	87 a	84 a
40 BR	263 a	122 a	91 a

For each site, means followed by the same letter are not significantly different ($p=0.05$). SP = seed placed P fertilizer; SB = side-banded P fertilizer; BR = broadcast P fertilizer.

Table 2. 2013 Midseason (R3 stage) Biomass Dry Matter (lb/acre)

Treatment	Brandon	Melita	Carberry	Beausejour	Arborg
Control	4955 a	6285 ab	5562 a	5002 a	4412 a
20 SP	5721 a	5104 a	5278 a	4308 ab	4983 a
20 SB	4752 a	4596 ab	6190 a	4220 ab	4280 a
20 BR	4062 a	5564 ab	6236 a	4183 ab	4809 a
40 SP	4783 a	5047 ab	4531 a	4878 a	4753 a
40 SB	4285 a	2968 ab	5813 a	4535 a	4739 a
40 BR	4757 a	4995 ab	5990 a	3049 b	4026 a
80 SP	4942 a	2549 b	5387 a	4059 ab	3588 a
80 SB	5041 a	4091 ab	6599 a	4420 ab	4660 a
80 BR	5533 a	6164 ab	6134 a	4787 a	3823 a

For each site, means followed by the same letter are not significantly different ($p=0.05$). SP = seed placed P fertilizer; SB = side-banded P fertilizer; BR = broadcast P fertilizer.

Table 3a. 2013 Seed Yield (bu/acre)

Treatment	Brandon	Melita	Carberry	Beausejour	Arborg
Control	35 a	59 a	52 a	57 a	35 ab
20 SP	32 a	56 a	54 a	60 a	40 ab
20 SB	33 a	48 ab	51 a	56 a	36 ab
20 BR	35 a	53 ab	47 ab	60 a	40 ab
40 SP	33 a	55 a	47 a	62 a	37 ab
40 SB	32 a	51 ab	49 a	59 a	36 ab
40 BR	34 a	56 a	53 a	62 a	39 ab
80 SP	27 a	38 b	37 b	64 a	36 b
80 SB	27 a	55 a	47 a	59 a	39 ab
80 BR	35 a	57 a	47 a	61 a	44 a

For each site, means followed by the same letter are not significantly different ($p=0.05$). SP = seed placed P fertilizer; SB = side-banded P fertilizer; BR = broadcast P fertilizer.

Table 3b. 2013 Seed Yield (bu/acre)

Treatment	Roblin	Portage	St Adolphe
Control	23 a	47 a	66 a
20 SP	24 a	43 a	69 a
20 BR	25 a	47 a	63 a
40 SP	23 a	45 a	72 a
40 BR	24 a	45 a	67 a

For each site, means followed by the same letter are not significantly different ($p=0.05$). SP = seed placed P fertilizer; SB = side-banded P fertilizer; BR = broadcast P fertilizer.

Table 4a. 2014 Stand Counts (thousand plants/acre)

Treatment	Arborg	Beausejour	Brandon	Carberry	Carman	Melita	Roseisle
Control	194 a	170 a	240 ab	163 ab	260 a	117 a	210 bc
20 SP	198 a	164 a	262 a	123 bcd	273 a	136 a	239 abc
20 SB	180 a	188 a	237 ab	201 a	239 a	178 a	198 c
20 BR	219 a	178 a	249 ab	146 bcd	257 a	147 a	235 abc
40 SP	194 a	179 a	233 ab	105 cd	268 a	134 a	244 abc
40 SB	170 a	173 a	245 ab	141 bcd	203 a	136 a	193 c
40 BR	208 a	168 a	233 ab	176 ab	245 a	134 a	238 abc
80 SP	195 a	161 a	187 b	100 d	203 a	136 a	269 ab
80 SB	228 a	161 a	234 ab	159 abc	257 a	159 a	188 c
80 BR	210 a	185 a	225 ab	156 abc	229 a	126 a	280 a

For each site, means followed by the same letter are not significantly different ($p=0.05$). SP = seed placed P fertilizer; SB = side-banded P fertilizer; BR = broadcast P fertilizer.

Table 4b. 2014 Stand Counts (thousand plants/acre)

Treatment	Roblin		Portage		St Adolphe	
Control	215	a	251	a	127	a
20 SP	194	a	159	abc	151	a
20 BR	193	a	237	ab	166	a
40 SP	216	a	155	bc	132	a
40 BR	169	a	218	abc	126	a
80 SP	194	a	125	c	126	a
80 BR	198	a	247	ab	147	a

For each site, means followed by the same letter are not significantly different ($p=0.05$). SP = seed placed P fertilizer; SB = side-banded P fertilizer; BR = broadcast P fertilizer.

Table 5. 2014 Midseason Biomass (R3 stage) Dry Matter (lb/ac)

Treatment	Carman		Roseisle		Carberry		Melita		Arborg		Beausejour		Brandon	
Control	3756	A	2114	a	3772	a	2690	a	3174	a	2781	a	2060	a
20 SP	3044	A	2627	a	2725	a	3229	a	3078	a	2598	a	2136	a
20 SB	3503	A	2131	a	4467	a	3529	a	3181	a	3134	a	2183	a
20 BR	3613	A	2341	a	3683	a	3392	a	3909	a	2958	a	2293	a
40 SP	3496	A	2076	a	2931	a	3280	a	3911	a	3158	a	2557	a
40 SB	4029	A	2346	a	3975	a	3254	a	3385	a	3323	a	2171	a
40 BR	3348	A	2171	a	3624	a	2555	a	3514	a	2667	a	2069	a
80 SP	3096	A	2355	a	3266	a	2512	a	3822	a	2190	a	1857	a
80 SB	3895	A	2693	a	3962	a	3238	a	3871	a	3146	a	2601	a
80 BR	4654	A	2511	a	3623	a	2894	a	3460	a	3501	a	2010	a

For each site, means followed by the same letter are not significantly different ($p=0.05$). SP = seed placed P fertilizer; SB = side-banded P fertilizer; BR = broadcast P fertilizer.

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