EFFECTIVENESS OF AVAIL FOR IMPROVING POTATO YIELD

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Introduction

Potato plants are very inefficient in their ability to utilize soil phosphorus (P) on some soils (Kelling et al., 1997). The optimum soil test P category for potato is more than three times greater than for other crops (Laboski et al., 2006). Being a high value crop, potato growers generally tend to apply more P fertilizer than recommended because it is inexpensive insurance if a yield response to applied P would occur. State nutrient management regulation requires growers to write and follow a nutrient management plan. This regulation also requires that nutrient application rates should conform to University of Wisconsin Extension (UWEX) guidelines. The potato growers feel that UWEX fertilizer recommendations for P are too low and could potentially reduce potato yield and quality.

Avail® is a relatively new fertilizer product that claims to improve P availability in the soil when coated on dry or mixed with liquid fertilizers. Avail® has a high cation exchange capacity and it is hypothesized that calcium, iron and aluminum bind to Avail® instead of P, thus allowing P to potentially be more available to plants (Murphy, 2005). Avail® coated MAP was shown to have some benefit for potato production in the calcareous soils of Idaho (Hopkins et al., 2005).

The objective of the study was to evaluate the effect of P rate and use of Avail® on potato yield and quality.

Materials and Methods

In 2006, research was conducted at six locations: Hancock and Spooner Ag Research Station (H6 and S6), and three grower fields (CF, WS6, TW), and Antigo Airport (A). In 2007, research was conducted at five locations: Hancock and Spooner Ag Research Station (H7 and S7) and three grower fields (WS7, TW1, TW2). Soil samples were collected prior to planting at 0-6" in each plot and composited within the replications. These samples were analyzed for P, K, Ca, Mg, pH, and organic matter (Table 1).

Potatoes were planted on 13, 27, 28 April and 3, 22, 23 May at H6, CF, WS6, S6, A, and TW locations, respectively in 2006. In 2007, potatoes were planted on 27, 30 April and 4, 23, 23 May at H7, WS7, S7, TW1, and TW2 locations, respectively. Russet Burbank potatoes were planted at H6, H7, CF, WS6, WS7, S6 and S7, using cut seed. Frito Lay 1867 was planted at A, TW, TW1, and TW2 locations using B size seed. At all locations except CF, TW1, and TW2 potatoes were planted in 36" rows with seed pieces being spaced approximately 12" apart. At CF, potatoes were planted in 30" rows with seed pieces being spaced approximately 12" apart. At TW1 and TW2 locations, potatoes were planted in 36" rows with seeds pieces being spaced 9" apart. Plot sizes were four rows wide and 20' long in 2006 and 2007 at all locations, except TW1 and TW2, which were six rows wide. The center two rows of each plot were harvest. Treatments are provided in Table 2. At planting, furrows were left open so that treatments could

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be applied; after treatments were applied the furrows were closed. The experimental design at all locations was randomized complete block with four replications.

All non-fertility cultural practices, including irrigation, were based on standard potato production practices. All potassium fertilizer was broadcast at planting as 0-0-60 at a rate of 100, 260, 60, 100, 220, and 60 lbs K_2O/a for H6, CF, WS6, A, S6, and TW locations, respectively in 2006. In 2007, 0-0-60 was broadcast at planting at a rate of 100 lb K_2O/a at all locations. In 2006, the total amount of nitrogen fertilizer applied (preplant and in season) at H6, CF, WS6, A, S6, and TW locations was 235, 208, 242, 75, 168, and 102 lb N/a. Nitrogen and potassium fertilizer rates varied by location based on soil test level and grower practices.

In 2006 at location H6, the second application of nitrogen at tuberization never occurred. Potatoes looked deficient on 12 July and additional applications of ammonium nitrate were applied on 17 and 24 July at a rate of 50 lb/a on both dates (these amounts are included in the total above). Early blight had already set in and these additional applications failed to revive the crop. Vines had senesced by 7 August and tubers failed to bulk properly.

Potatoes were harvested on 19, 26, 26 September and 2, 4, 6 October for S6, A, TW, WS6, CF, and H6 locations, respectively in 2006. Harvest dates for 2007 were 18, 20, 20, 26 September and 8 October for WS7, TW1, TW2, S7 and H7 locations, respectively. All potatoes were graded and specific gravity measured at Hancock ARS with the exception of the potatoes at location S which were graded at Spooner ARS. The grading system at Spooner separates tubers into two classes (A and B) while the grading system at Hancock separate tubers in seven classes (B, < 4 oz., 4 to 6 oz., 6 to 10 oz., 10 to 13 oz., 13 to 16 oz., and > 16 oz.).

Tubers were analyzed by total yield, marketable yield (total yield – culls), and mean tuber size. Mean tuber size (oz.) is the weighted average tuber size based on the proportion of marketable yield in each size class (Bussan et al., 2007). Mean tuber size was not calculated at Spooner because the tubers were not graded in enough different size classes to make the calculation useful. A generalized linear model was used to assess source by rate interactions and the effect of rate. Analysis were considered statistically significant if $p<0.10$. The effect of source on yield was assessed with contrasts of MAP+Avail or TSP/MAP at the same rates applied.

Results and Discussion

The results presented below represent the 2006 and 2007 season. For locations H6, H7, CF, WS6 WS7, A, TW, TW1, and TW2 the tuber classes analyzed were total tuber yield, marketable tuber yield, and mean tuber size. At locations S6 and S7, the grading system doesn't allow for tuber classes to be graded out. Yield differences between P treatments were generally not statistically significant ($p<0.10$). Thus, the discussion will focus on specific locations and yields where P treatments produced significantly different yields.

Russet Burbank

There were no significant source by rate interactions for total yield, marketable yield, or mean tuber size in 2006 (Table 3.) Application of P (rate) significantly increased marketable tuber yield at CF and S6 and total tuber yield at S6. At all other locations as P fertilizer application rate increased, yield or mean tuber size did not significantly ($p<0.10$) increase. In 2007 at locations H7, WS7, and S7 there was no significant source by rate interaction for total yield, marketable yield, and mean tuber size (Table 4) and application of P did not significantly

increase yield. When compared to the control, addition of 65 lb P_2O_5/a as TSP or MAP positively increased marketable yield at five of seven locations, though not always significant. On average, marketable yield was increased by 40 cwt/a at five locations and decreased by 19 cwt/a at two locations. The large marketable yield increase that occurred at CF was unexpected because the soil test P level was excessively high (Table 1). The lack of a response to P fertilizer at location H6 was unexpected because the soil test P level was low; however, it must be remembered that tubers at this location failed to bulk, thus interpreting these results for processing potatoes may be limited.

There was no significant increase in mean tuber size. Thus, the yield increases that did occur were the result of an increase in tuber number and not an increase in mean tuber size (Tables 3 and 4).

The effect of P source (Avail) on yield and tuber size was also assessed. Avail+MAP significantly increased yield compared to TSP at location S6 in 2006 (Table 3). At the other locations in 2006 (H6, CF, and WS6), marketable tuber yield was increased by 46.5 cwt/a on average with Avail+MAP compared to TSP, though these yield increases were not significant. In 2007 Avail+MAP did increased yield on average by 4 cwt/a at H7 and S7 and reduced yield by 15 cwt/a at WS7 compared to MAP; though none of these yield differences were significant. The yield increases with application of Avail in 2006 may be caused by the fact that the Avail was coated on MAP and was being compared to P supplied from TSP. P uptake is often stimulated by ammonium. Thus yield increases may have been caused by supplying ammonium with the phosphate, even though rate of N supplied in every treatment was the same.

Frito Lay 1867

There was no significant source by rate interactions at any of the locations where Frito Lay 1867 was grown (Tables 5 and 6). Application of P fertilizer significantly increased marketable and total yield at location A and TW2. The addition of 65 lb P_2O_5/a TSP or MAP increased marketable tuber yield compared to the control at all locations, though not always significantly; the average yield increase was 28.0 cwt/a. Mean tuber size was not affected by P fertilizer application rate.

MAP+Avail was compared to TSP/MAP to determine the impact of Avail on yield and mean tuber size. Application of MAP+Avail significantly increased marketable yield compared to TSP at location A. The change in yield with MAP+Avail compared to TSP or MAP was 29.8, 2.6, -8.2 and 9.4 cwt/a. Mean tuber size was significantly increased with Avail at location A and significantly decreased at location TW1. At TW and TW2 mean tuber size tended to be somewhat lower when Avail+MAP was applied compared to TSP/MAP. A small reduction in mean tuber size coupled with slightly larger yields indicates that more tubers were initiated and tubers remained smaller in Avail treated plots.

Conclusions

For Russet Burbank, yield increases in 2006 when Avail+MAP was applied compared to TSP may have been caused by not comparing the exact same fertilizer materials. In 2007, when Avail+MAP was compared to MAP, yield increases were small and yield decreased at one location when Avail was applied. Avail had no significant effect on mean tuber size for Russet Burbank.

For Frito Lay 1867, use of Avail resulted in increases and decreases in marketable yield compared to TSP or MAP. When Avail was applied with MAP compared to MAP or TSP alone, mean tuber size was smaller at three locations, though only significant at one location. Because this variety is grown for seed, a smaller tuber size is desirable. If Avail can consistently produce tubers with a somewhat smaller size, then the cost of Avail (approx. $5-7/a) may be an economical investment for seed potato growers.

Marketable Russet Burbank tuber yield was maximized with application of 65 lb P_2O_5/a on coarse-textured soils with soil test levels ranging from very low to excessively high. On silt loam soils, marketable Frito Lay 1867 yield was maximized with application of 65 lb P_2O_5/a on high P testing soils and with application of 130 lb P_2O_5/a on low and optimum P testing soils.

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Table 1. Soil characterization and initial soil test analysis.

Location	Soil name†	Taxanomic name	P*	P fert. rec.‡	pH	OM
			ppm	lb P_2O_5/a		%
2006						
H6	Plainfield s	Mixed, mesic Typic Udipsamments	62 (L)	130	6.6	1.3
CF	Sparta ls	Sandy, mixed, mesic Entic Hapuldolls	246 (EH)	30	6.6	1.6
WS6	Richford ls	Loamy, mixed superactive, mesic Arenic Hapludalfs	186 (EH)	30	6.0	1.1
S6	Mahtomedi ls	Mixed, frigid Typic Udipsamments	35 (VL)	155	6.4	2.0
A	Antigo sil	Coarse-loamy over sandy, mixed, superactive, frigid Haplic Glossudalfs	265 (H)	75	5.7	2.6
TW	Antigo sil	Coarse-loamy over sandy, mixed, superactive, frigid Haplic Glossudalfs	242 (H)	75	5.5	2.8
2007						
H7	Plainfield s	Mixed, mesic Typic Udipsamments	48 (VL)	155	6.8	1.4
WS7	Coloma s	Mixed, mesic Lamellic Udipsamments	152 (H)	75	6.4	1.4
S7	Cress sl	Sandy, mixed, frigid Humic Dystrudepts	90 (VL)	250	6.8	1.4
TW1	Antigo sil	Coarse-loamy over sandy, mixed, superactive, frigid Haplic Glossudalfs	140 (L)	190	5.0	3.1
TW2	Antigo sil	Coarse-loamy over sandy, mixed, superactive, frigid Haplic Glossudalfs	180 (O)	90	5.3	2.8

† ls, loamy sand; s, sand; sl, sandy loam; sil, silt loam.

* Soil test P level with interpretation category in parenthesis. L, low; O, optimum; H, high, EH, excessively High.

‡ P fert. rec., phosphorus fertilizer recommendation is based on soil test P levels and interpretation categories in Laboski et at. (2006).

Table 2. Treatments for all locations in 2006 and 2007.

Treatment	P source*	P rate	P timing†
		lb P_2O_5/a	
2006-All locations except S6			
1	None	0	None
2	TSP	65	Starter
3	TSP	130	Starter
4	MAP+Avail	65	Starter
2006-S6			
1	None	0	None
2	TSP	65	Starter
3	TSP	130	Starter
4	TSP	195	Starter
5	TSP	260	Starter
6	MAP+Avail	130	Starter
7	MAP+Avail	195	Starter
2007-All locations except S7			
1	None	0	None
2	MAP	65	Starter
3	MAP	130	Starter
4	MAP+Avail	65	Starter
5	MAP+Avail	130	Starter
2007-S7			
1	None	0	None
2	MAP	65	Starter
3	MAP	130	Starter
4	MAP	195	Starter
5	MAP+Avail	65	Starter
6	MAP+Avail	130	Starter
7	MAP+Avail	195	Starter

*TSP, triple super phosphate (0-46-0); MAP, monoammonium phosphate (11-52-0).
†Starter, fertilizer applied at planting approximately 5 cm to the side of the seed piece.

Table 3. Russet Burbank yield and specific gravity for locations H6, CF, WS6, and S6 in 2007.

P source†	P rate	Yield		Mean tuber size	S.G.§
		Total	Marketable‡		
	P_2O_5/a	---------- cwt/a ----------		oz.	
Location H6					
None	0	458.2	430.8	4.99	1.075
TSP	65	441.2	416.9	4.38	1.075
TSP	130	429.4	413.0	4.48	1.075
MAP+Avail	65	492.1	455.1	4.25	1.079
Source x rate	*p*	0.248	0.457	0.683	0.013*
Rate	*p*	0.567	0.767	0.103	0.107
Source	*p*	0.234	0.281	0.599	0.0006*
CV,%		11.35	11.67	8.18	0.138
Location CF					
None	0	603.7	528.1	8.20	1.074
TSP	65	625.6	610.3	7.95	1.079
TSP	130	640.4	591.9	8.38	1.080
MAP+Avail	65	703.8	651.5	7.92	1.079
Source x rate	p	0.287	0.344	0.526	0.923
Rate	p	0.413	0.048*	0.547	0.349
Source	p	0.205	0.428	0.938	0.799
CV,%		10.45	8.93	7.69	0.367
Location WS6					
None	0	511.5	427.5	5.71	1.058
TSP	65	512.6	403.8	5.93	1.066
TSP	130	513.8	413.5	6.04	1.063
MAP+Avail	65	558.7	461.8	5.89	1.071
Source x rate	p	0.746	0.618	0.896	0.562
Rate	p	0.878	0.941	0.680	0.233
Source	p	0.387	0.307	0.937	0.529
CV,%		18.01	20.34	7.85	0.982
Location S6					
None	0	398.9	235.8	-	-
TSP	65	469.8	272.4	-	-
TSP	130	506.2	321.9	-	-
TSP	195	527.7	316.1	-	-
TSP	260	503.2	341.3	-	-
MAP+Avail	130	564.5	384.2	-	-
MAP+Avail	195	553.6	381.9	-	-
Source x rate	p	0.126	0.176	-	-
Rate	p	0.0007*	0.027*	-	-
Source	p	0.038*	0.062*	-	-
CV,%		9.47	19.10	-	-

† TSP, triple superphosphate (0-46-0); MAP, monoammonium phosphate (11-52-0).
‡ Marketable tuber yield = Total yield – cull tuber yield.
* Values are significantly different at the $p<0.10$ probability level.
§S.G., specific gravity.

Table 4. Russet Burbank yield and specific gravity for locations H7, WS7, and S7 in 2007.

P source†	P rate	Yield		Mean tuber size	S.G.§
		Total	Marketable‡		
	P_2O_5/a	---------- cwt/a ----------		oz.	
Location H7					
None	0	532.3	495.1	5.83	1.080
MAP	65	560.8	514.2	6.18	1.081
MAP	130	556.3	515.7	5.74	1.082
MAP+Avail	65	555.5	521.5	6.01	1.080
MAP+Avail	130	559.3	519.6	5.77	1.080
Source x rate	p	0.997	0.939	0.486	0.929
Rate	p	0.501	0.529	0.367	0.836
Source	p	0.951	0.561	0.765	0.509
CV,%		7.22	7.39	7.57	0.296
Location WS7					
None	0	372.2	352.4	4.62	1.079
MAP	65	428.3	398.1	4.70	1.082
MAP	130	429.4	385.8	4.95	1.083
MAP+Avail	65	393.3	369.1	5.30	1.083
MAP+Avail	130	412.4	385.1	4.73	1.086
Source x rate	p	0.771	0.855	0.303	0.293
Rate	p	0.328	0.459	0.449	0.038*
Source	p	0.328	0.509	0.444	0.329
CV,%		13.25	12.20	9.67	0.263
Location S7					
None	0	384.2	310.2	-	-
MAP	65	404.9	327.5	-	-
MAP	130	383.9	307.8	-	-
MAP	195	402.6	356.9	-	-
MAP+Avail	65	391.3	326.2	-	-
MAP+Avail	130	380.6	321.2	-	-
MAP+Avail	195	393.9	352.3	-	-
Source x rate	p	0.938	0.669	-	-
Rate	p	0.777	0.197	-	-
Source	p	0.412	0.910	-	-
CV,%		10.50	14.19	-	-

† TSP, triple superphosphate (0-46-0); MAP, monoammonium phosphate (11-52-0).
‡ Marketable tuber yield = Total yield – cull tuber yield.
* Values are significantly different at the $p<0.10$ probability level.
§S.G., specific gravity.

Table 5. FL 1867 yield and specific gravity for locations A and TW in 2006.

P source†	P rate	Yield		Mean tuber size	S.G.§
		Total	Marketable‡		
	P_2O_5/a	---------- cwt/a ----------		oz.	
Location A					
None	0	223.6	189.3	6.25	1.075
TSP	65	271.3	236.1	6.31	1.073
TSP	130	284.7	225.6	6.32	1.080
MAP+Avail	65	292.5	265.9	6.72	1.079
Source x rate	p	0.787	0.133	0.639	0.579
Rate	p	0.063*	0.012*	0.801	0.684
Source	p	0.105	0.018*	0.008*	0.489
CV,%		15.30	10.74	10.46	0.836
Location TW					
None	0	444.3	426.2	5.93	1.073
TSP	65	476.0	438.7	5.80	1.070
TSP	130	456.1	434.3	5.51	1.071
MAP+Avail	65	465.1	441.3	5.59	1.074
Source x rate	p	0.579	0.858	0.450	0.749
Rate	p	0.277	0.514	0.159	0.912
Source	p	0.485	0.743	0.431	0.331
CV,%		5.59	4.19	5.61	0.869

† TSP, triple superphosphate (0-46-0); MAP, monoammonium phosphate (11-52-0).
‡ Marketable tuber yield = Total yield – cull tuber yield.
* Values are significantly different at the $p<0.10$ probability level.
§S.G., specific gravity.

Table 6. FL 1867 yield and specific gravity for locations TW1 and TW2 in 2007.

P source†	P rate	Yield		Mean tuber size	S.G.§
		Total	Marketable‡		
	P_2O_5/a	---------- cwt/a ----------		oz.	
Location TW1					
None	0	364.1	347.3	4.36	1.094
MAP	65	394.2	380.3	4.68	1.091
MAP	130	412.1	393.6	4.52	1.092
MAP	195	410.1	393.9	4.54	1.095
MAP+Avail	65	392.0	379.3	4.42	1.093
MAP+Avail	130	391.9	377.9	4.23	1.094
MAP+Avail	195	401.5	385.9	4.22	1.093
Source x rate	p	0.920	0.957	0.450	0.403
Rate	p	0.329	0.243	0.729	0.562
Source	p	0.437	0.497	0.051*	0.829
CV,%		8.66	8.30	8.36	0.249
Location TW2					
None	0	415.1	392.5	4.49	1.091
MAP	65	435.9	412.3	4.59	1.094
MAP	130	443.4	426.1	4.77	1.088
MAP	195	438.9	421.3	4.66	1.091
MAP+Avail	65	447.1	426.8	4.41	1.092
MAP+Avail	130	431.2	407.4	4.57	1.096
MAP+Avail	195	470.6	453.8	4.70	1.088
Source x rate	p	0.270	0.167	0.380	0.0007*
Rate	p	0.084*	0.048*	0.237	0.559
Source	p	0.318	0.391	0.257	0.499
CV,%		5.30	5.71	5.10	0.222

† TSP, triple superphosphate (0-46-0); MAP, monoammonium phosphate (11-52-0).
‡ Marketable tuber yield = Total yield – cull tuber yield.
* Values are significantly different at the $p<0.10$ probability level.
§S.G., specific gravity.