

**Optimizing Phosphorus Fertilizer Management for Maximum Phosphorus Use Efficiency
and Maximum Economic Returns in Potato Production**

2021 Research Report

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Introduction

With increasing cost of fertilizers, it has become more important than ever to optimize fertilizer application for increased yield and maximum economic returns. Various liquid phosphorus (P) fertilizers have emerged on the market. However, their agronomic use efficiencies in potato production have not been well documented.

The objective of this project was to evaluate tuber yield and tuber quality response of russet potato to application of blended liquid P fertilizers. The study also investigated the economic returns of applying blended liquid P fertilizers as compared to applying 10-34-0 alone as source of P fertilizer.

Experimental Procedure

The field study was laid out as randomized complete block design. Potato cultivar Canela Russet was used in the study. Liquid P fertilizers used in the study and their current prices included 8-21-5 (\$6.25/gallon), 3-18-18 (\$7.50/gallon), 9-24-3 (\$5.92/gallon), and 8-22-2 (\$6.48/gallon). 10-34-0 (\$3.60/gallon) is the standard liquid P fertilizer commonly used in Colorado. It is cheaper compared to other liquid P fertilizers and was therefore used as the control P fertilizer in the study.

Treatments consisted of blending 15 lbs of the relatively more expensive liquid P fertilizers with 85 lbs or 68 lbs of the less expensive and standard 10-34-0 P fertilizer. Phosphorus fertilizer treatments consisted of the following, T1=8-21-5/10-34-0 (15/85 lb P/Acre); T2= 8-21-5/10-34-0 (15/68 lb P/Acre); T3= 3-18-18/10-34-0 (15/85 lb P/Acre); T4= 3-18-18/10-34-0 (15/68 lb P/Acre); T5 = 9-24-3/10-34-0 (15/85 lb P/Acre); T6 = 9-24-3/10-34-0 (15/68 lb P/Acre); T7 = 8-22-2/10-34-0 (15/85 lb P/Acre); T8 = 8-22-2/10-34-0 (15/68 lb P/Acre); T9 = Control (10-34-0) – 100 lb P/Acre. Each treatment was replicated four times.

Soil P analysis of the experimental site indicated a residual soil P of 170 lbs P/acre (Mehlich 3). Phosphorus fertilizer was banded. A cost – benefit analysis was conducted to evaluate net returns from the application of each P fertilizer treatment. In calculating net returns, all operational costs were fixed for all treatments, except the cost of P fertilizer which varied for each treatment.

Results

Petiole Phosphorus Concentration

Phosphorus fertilizer blends applied in this study did influence petiole P concentration. In general, P fertilizer blends with 85 lb of 10-34-0 showed higher petiole P concentration compared to the same blend with 68 lbs of 10-34-0 (fig 1). With the exception of 8-21-5 blended with 85 lbs of 10-34-0 (T!), the application of 10-34-0 as sole source of P fertilizer increased petiole P concentration from 83 to 97 days after planting, compared to all other treatments (fig 1). Blending higher rates of 10-34-0 (85 lb P) with other liquid P fertilizers improved P uptake

and concentration in the petioles. It should be noted that petiole p concentration varied for each blend during the growing season.

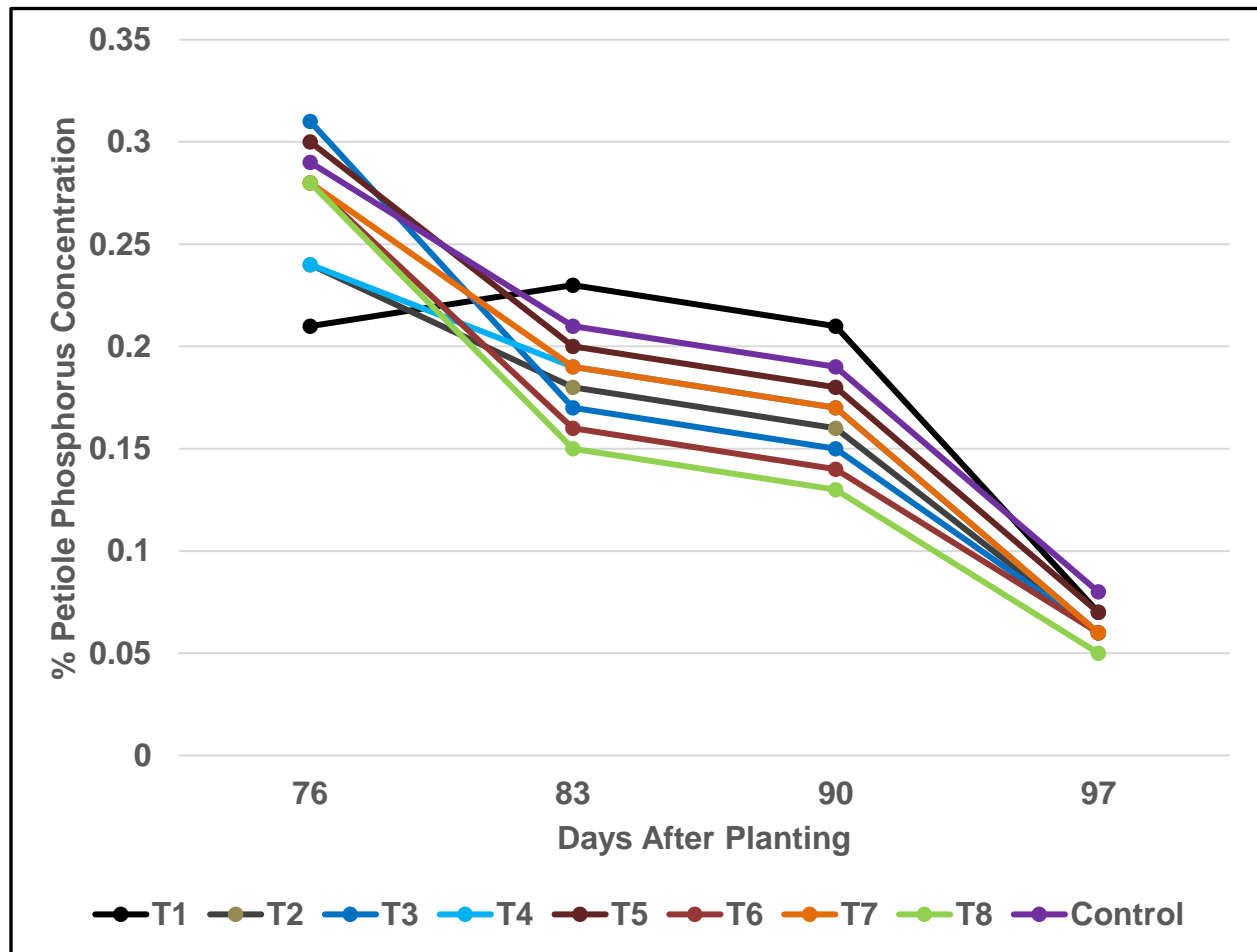


Figure 1. Effect of application of liquid P fertilizer blends on petiole phosphorus concentration during the growing season, 2021.

Agronomic Phosphorus Use Efficiency (APUE)

Agronomic P Use Efficiency measures the quantity of potatoes produced for every pound of P fertilizer applied. For every P fertilizer blend applied in the study, the blend with 68 lb 10-34-0 P/acre used P more efficiently than the blend with 85 lb 10-34-0 P/acre for the 4-16 oz and > 6 oz tuber yields (Table 1). Similar observations were made for the > 10 oz tuber yields, with the exception of 3-18-18 which had a higher P use efficiency with the 85 lb 10-34-0 P/acre (T3) than the 68 lb 10-34-0 P/acre (T4) - Table 1.

Table 1 Effect of application of liquid phosphorus fertilizer blends on phosphorus use efficiency of Canela Russet, 2021

<u>Treatment</u>	<u>Phosphorus Use Efficiency (cwt/lb P)</u>		
	<u>4-16 oz</u>	<u>> 6 oz</u>	<u>> 10 oz</u>
1 ^y	3.7 b ^x	2.9 b	1.0 b
2	4.4 a	3.3 a	1.4 a
3	3.8 b	3.1 b	1.4 a
4	4.5 a	3.6 a	1.3 b
5	3.5 b	2.9 b	1.3 b
6	4.5 a	3.9 a	1.5 a
7	3.5 b	2.9 b	1.2 b
8	4.2 a	3.6 a	1.5 a
9 (control)	3.4 b	2.8 b	1.0 b

^y 1 = 15 lb 8-21-5/85 lb 10-34-0; 2 = 15 lb 8-21-5/68 lb 10-34-0; 3 = 15 lb 3-18-18/85 lb 10-34-0
 4 = 15 lb 3-18-18/68 lb 10-34-0; 5 = 15 lb 9-24-3/85 lb 10-34-0; 6 = 15 lb 9-24-3/68 lb 10-34-0;
 7 = 15 lb 8-22-2/85 lb 10-34-0; 8 = 15 lb 8-22-2/68 lb 10-34-0
 9 = 10-34-0 (100 lb P/acre) - control

^x Figures in the same column and bearing the same letters are not significantly different at 0.05 level of probability.

Tuber Yield and Tuber Size Distribution

Blending 10-34-0 with other liquid P fertilizers increased tuber yield of Canela Russet. 3-18-18 blended with 85 lb 10-34-0 P/acre (T3) increased total, > 4oz, 4-16 oz, > 10 oz, and 10-16 oz tuber yields, compared to applying 10-34-0 as the only source of P fertilizer (control) – Table 2. A blend of 9-24-3 with 68 lbs 10-34-0 P/acre (T6) increased > 4 oz, 4-16 oz, > 6 oz, 6-16 oz, and > 10 oz tuber yields, compared to the control treatment (Table 2).

8-21-5 blended with 68 lb 10-34-0 P/acre (T2) increased the yield of 10-16 oz tubers compared

to the control. Blending 8-22-2 with 68 lbs 10-34-0 P/acre (T8) increased > 10 oz and 10-16 oz tuber yields, compared to the control treatment (Table 2).

It was observed that each liquid P fertilizer evaluated in the study had its unique advantage in terms of which tuber size group improves in yield when blended with 10-34-0.

Net Returns from Applying Blended Liquid P Fertilizers

A cost-benefit analysis of the yield data showed higher net returns on 4-16 oz and > 10 oz tuber yields when 10-34-0 was blended with any of the liquid P fertilizers evaluated in the study, compared to applying 10-34-0 as the sole source of P fertilizer (Table 3). With the exception of 8-21-5 blended with 68 lb 10-34-0 P/Acre (T2), all other blended P fertilizers increased net returns for > 6 oz tuber yields, compared to the control treatment (Table 3).

For 4-16 oz tuber yields, 3-18-18 blended with 85 or 68 lb 10-34-0 P/acre (T3 or T4), 9-24-3 blended with 68 lb 10-34-0 P/acre (T6), and 8-21-5 blended with 68 lb 10-34-0 P/acre (T2), produced the highest net returns of \$4,006.00, \$3,999.00, \$3,997.00, and \$3,941, respectively. For > 6 oz tuber yield, 9-24-3 blended with 68 lb 10-34-0 P/acre (T6), 3-18-18 blended with 85 lb 10-34-0 P/acre (T3), and 8-22-2 blended with 68 lb 10-34-0 P/acre (T8), produced the highest net returns of \$4,130.00, \$3,861.00, and \$3,746.00, respectively, compared to the application of 10-34-0 as sole source of P fertilizer.

Evaluation of > 10 oz tuber yield showed that blended application of 3-18-18 or 9-24-3 with 85 lb 10-34-0 P/acre (T3 or T5), blended application of 8-22-2 or 9-24-3 with 68 lb 10-34-0 P/acre (T8 or T6), increased net returns by \$2,372.00, \$2,176.00, \$2,166.00, and \$2,155, respectively (Table 3).

Table 2 Yield response of Russet potato to application of blended phosphorus fertilizers, 2021

<u>Treatment</u>	<u>Total</u>	<u>≥ 4 oz</u>	<u>4-16 oz</u>	<u>≥ 6 oz</u>	<u>6-16 oz</u>	<u>≥ 10 oz</u>	<u>10-16 oz</u>
	<u>Tuber Yield (cwt/acre)</u>						
1 ^y	422 <i>ab</i> ^x	376 <i>ab</i>	369 <i>ab</i>	290 <i>ab</i>	284 <i>ab</i>	103 <i>d</i>	96 <i>bc</i>
2	413 <i>b</i>	370 <i>ab</i>	362 <i>ab</i>	277 <i>b</i>	269 <i>b</i>	115 <i>bcd</i>	107 <i>ab</i>
3	450 <i>a</i>	391 <i>a</i>	376 <i>a</i>	307 <i>ab</i>	292 <i>ab</i>	139 <i>a</i>	124 <i>a</i>
4	420 <i>ab</i>	381 <i>ab</i>	374 <i>a</i>	296 <i>ab</i>	288 <i>ab</i>	106 <i>cd</i>	98 <i>abc</i>
5	428 <i>ab</i>	374 <i>ab</i>	351 <i>ab</i>	292 <i>ab</i>	269 <i>b</i>	127 <i>ab</i>	104 <i>abc</i>
6	437 <i>ab</i>	392 <i>a</i>	372 <i>a</i>	325 <i>a</i>	305 <i>a</i>	125 <i>abc</i>	105 <i>abc</i>
7	411 <i>b</i>	357 <i>b</i>	349 <i>ab</i>	286 <i>b</i>	277 <i>ab</i>	117 <i>bcd</i>	109 <i>ab</i>
8	410 <i>b</i>	366 <i>ab</i>	351 <i>ab</i>	296 <i>ab</i>	281 <i>ab</i>	126 <i>abc</i>	111 <i>ab</i>
9 (control)	409 <i>b</i>	357 <i>b</i>	338 <i>b</i>	280 <i>b</i>	260 <i>b</i>	99 <i>d</i>	79 <i>c</i>

^y 1 = 15 lb 8-21-5/85 lb 10-34-0; 2 = 15 lb 8-21-5/68 lb 10-34-0; 3 = 15 lb 3-18-18/85 lb 10-34-0; 4 = 15 lb 3-18-18/68 lb 10-34-0

5 = 15 lb 9-24-3/85 lb 10-34-0; 6 = 15 lb 9-24-3/68 lb 10-34-0; 7 = 15 lb 8-22-2/85 lb 10-34-0; 8 = 15 lb 8-22-2/68 lb 10-34-0

9 = 10-34-0 (100 lb P/acre) - control

^x figures in the same column and bearing the same letters are not significantly different at the 0.05 level of probability

Table 3. Effect of applying blended liquid P fertilizers on net returns when considering P fertilizer cost only, with all other costs fixed, 2021.

Treatment	<u>4-16 oz</u>	<u>> 6 oz</u>	<u>> 10 oz</u>
	Net Returns (\$/Acre)		
1 ^y	3,941.00	3,652.00	1,736.00
2	3,879.00	3,498.00	1,967.00
3	4,006.00	3,861.00	2,372.00
4	3,999.00	3,733.00	1,793.00
5	3,751.00	3,686.00	2,176.00
6	3,997.00	4,130	2,155.00
7	3,722.00	3,601.00	1,989.00
8	3,759.00	3,746.00	2,166.00
9 (control)	3,628.00	3,550.00	1,692.00

^y 1 = 15 lb 8-21-5/85 lb 10-34-0; 2 = 15 lb 8-21-5/68 lb 10-34-0; 3 = 15 lb 3-18-18/85 lb 10-34-0
 4 = 15 lb 3-18-18/68 lb 10-34-0; 5 = 15 lb 9-24-3/85 lb 10-34-0; 6 = 15 lb 9-24-3/68 lb 10-34-0;
 7 = 15 lb 8-22-2/85 lb 10-34-0; 8 = 15 lb 8-22-2/68 lb 10-34-0;
 9 = 10-34-0 (100 lb P/acre) - control

Summary

Data from this study indicate that blending 10-34-0 with other liquid P fertilizers improves P use efficiency, increases tuber yield and quality, and generates higher economic returns compared to applying 10-34-0 as the only source of P fertilizer in potato production.

It should be noted that the liquid P fertilizers evaluated in this study are unique in their P use efficiencies for different tuber size groups. Potato growers should therefore decide which of the tuber size groups is of importance to their operation, and then decide which P fertilizer blend to use.