

Response of Russet Potato to Source and Rate of Phosphorus Fertilizer Application

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Study Objective

The objective of this study was to evaluate the effect of source and rate of phosphorus (P) fertilizer application on potato plant P uptake as evidenced by petiole P concentration and total plant P concentration. The effect of the treatments on potato tuber yield, tuber size distribution, and tuber quality were also evaluated.

Materials and Methods

Study Site, Experimental Design, and Treatments

The field study was conducted at the San Luis Valley Research Center, Colorado State University, during the 2013 potato growing season.

The study was laid out as a factorial arrangement of the treatments in a randomized complete block design. Treatments included six P fertilizer sources (MAP, MAP + AVAIL®, MESZ, MESZ + AVAIL, 40 ROCK™, and 40 ROCK + AVAIL) each applied at two rates (50 and 100 lbs. P₂O₅ per acre). A control treatment was included where no P fertilizer was applied. The treatment combinations were as follows:

1. Control
2. MAP 50 (50 lbs/ac P₂O₅ applied)
3. MAP 100 (100 lbs/ac P₂O₅ applied)
4. MAP + AVAIL 50 (50 lbs/ac P₂O₅ applied)
5. MAP + AVAIL 100 (100 lbs/ac P₂O₅ applied)
6. MESZ 50 (50 lbs/ac P₂O₅ applied)
7. MESZ 100 (100 lbs/ac P₂O₅ applied)
8. MESZ + AVAIL 50 (50 lbs/ac P₂O₅ applied)
9. MESZ + AVAIL 100 (100 lbs/ac P₂O₅ applied)
10. 40 ROCK 50 (50 lbs/ac P₂O₅ applied)
11. 40 ROCK 100 (100 lbs/ac P₂O₅ applied)
12. 40 ROCK + AVAIL 50 (50 lbs/ac P₂O₅ applied)
13. 40 ROCK + AVAIL 100 (100 lbs/ac P₂O₅ applied)

Each treatment was replicated four times.

Data Collection and Plant Analysis

Petiole samples were taken from 56 to 77 days after planting (DAP) for petiole P concentration analysis. During tuber bulking, whole plant samples were taken from each plot for total plant P concentration analysis. Oven dried samples from replicated plots were composited and analyzed for each treatment.

At harvest, tubers from each plot were weighed for total yield. The harvested tubers were separated into various size distribution groups based on weight (4–10 oz and 10–16 oz).

Tubers harvested from each plot were evaluated for external (growth cracks, knobs, and misshapes) and internal (hollow heart and brown center) defects.

Ten large tubers were randomly selected from each plot for tuber specific gravity evaluation. Tuber specific gravity was measured using the weight-in-air/weight-in-water method.

Results and Discussion

Petiole Phosphorus (P) Concentration

Among the thirteen treatments, petiole P concentration was observed to be highest in plants that received 40 ROCK 100 and 40 ROCK + AVAIL 100, with the exception of the P concentration at 63 DAP, which was midway lower in plants that received 40 ROCK 100 (Fig. 1a).

When all sources of P fertilizer applied at 50 lbs P_2O_5 /ac were compared with each other, petiole P concentration was observed to be highest for 40 ROCK + AVAIL 50, from 59 to 72 DAP. The two treatments that showed high petiole P concentration than 40 ROCK + AVAIL 50 were MESZ 50 at 56 DAP and MAP 50 and 40 ROCK 50 at 77 DAP (Fig. 1b).

All sources of P fertilizer applied at 100 lbs P_2O_5 /ac showed 40 ROCK and 40 ROCK + AVAIL having the highest concentration of P in the petioles. The only exception was 40 ROCK 100, which showed a lower petiole P concentration midway at 63 DAP (Fig. 1c).

Comparing the rate of MAP application on petiole P concentration, it was observed that in general MAP 100 and MAP + AVAIL 100 had the highest petiole P concentration (Fig. 1d). Similarly, for MESZ as the source of P fertilizer, MESZ 100 and MESZ + AVAIL 100 showed the highest petiole P concentration, with the exception of MESZ 50, which showed higher petiole P concentration at 56 DAP (Fig. 1 e). With 40 ROCK as the source of P fertilizer, 40 ROCK 100 and 40 ROCK + AVAIL 100 showed higher petiole P concentrations, compared to all other application rates. The only exception was at 63 DAP when 40 ROCK 100 showed lower P concentration than 40 ROCK + AVAIL 50 (Fig. 1 f).

When all sources and rates of P fertilizer containing AVAIL were compared to each other, 40 ROCK + AVAIL 100 showed the highest concentration of petiole P (Fig 1g). For all sources and rates of P fertilizer applied without any AVAIL added, 40 ROCK 100 showed the highest concentration of P in the petioles. The only exception was at 63 DAP when MESZ 100 showed higher petiole P concentration (Fig. 1 h).

The petiole P concentration analysis indicated that Rio Grande Russet potato responded to source and rate of P fertilizer application, with 40 ROCK 100 or 40 ROCK + AVAIL 100 showing the highest concentration of P in the petioles.

In all the comparisons made in this study, the control treatment showed the lowest petiole P concentration, indicating that phosphorus was absorbed by the plant when P fertilizer was applied.

Figure 1. Effect of source and rate of phosphorus fertilizer application on petiole P concentration of Rio Grande Russet potato, 2013.

Figure 1a

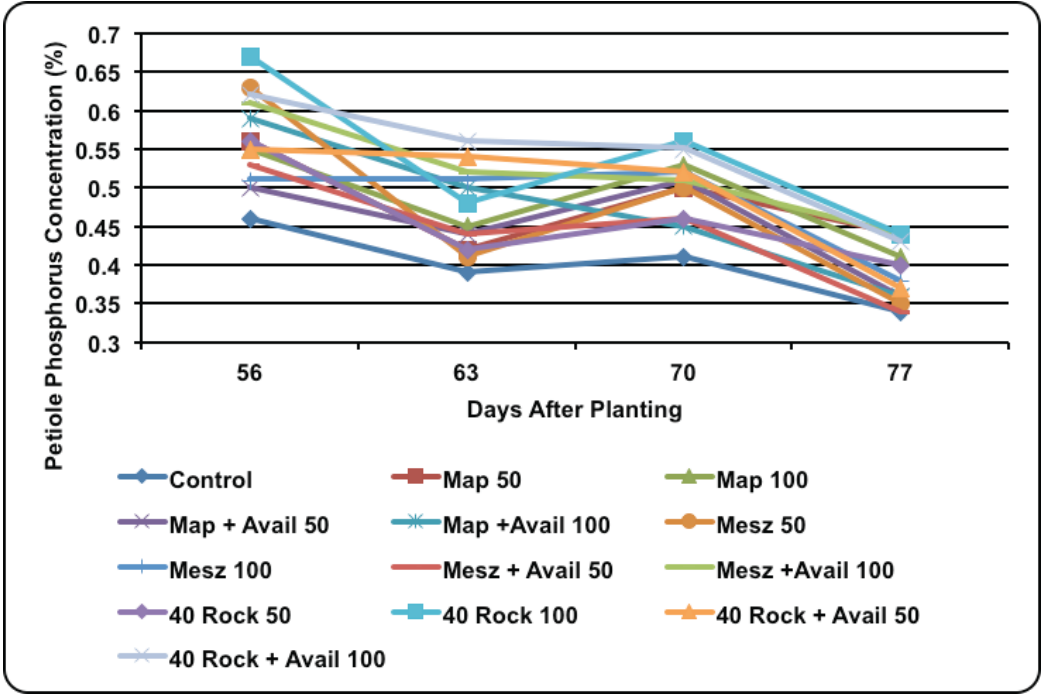


Figure 1a. Compares all sources and rates of P fertilizer.

Figure 1b

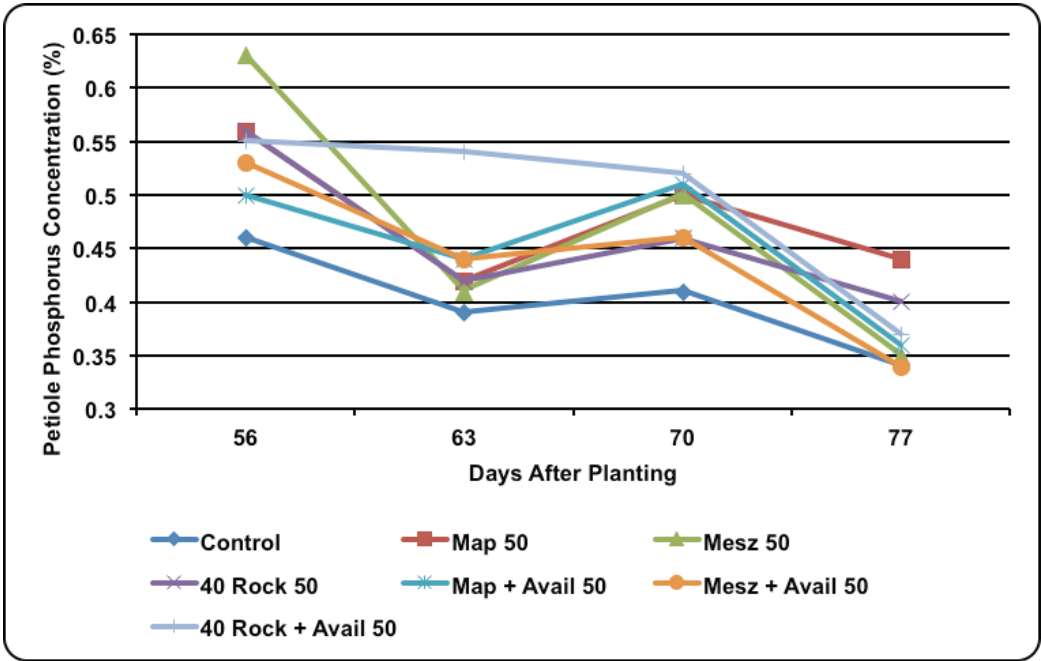


Figure 1b. Compares all fertilizer sources applied at 50 lbs P₂O₅/ac.

Figure 1c

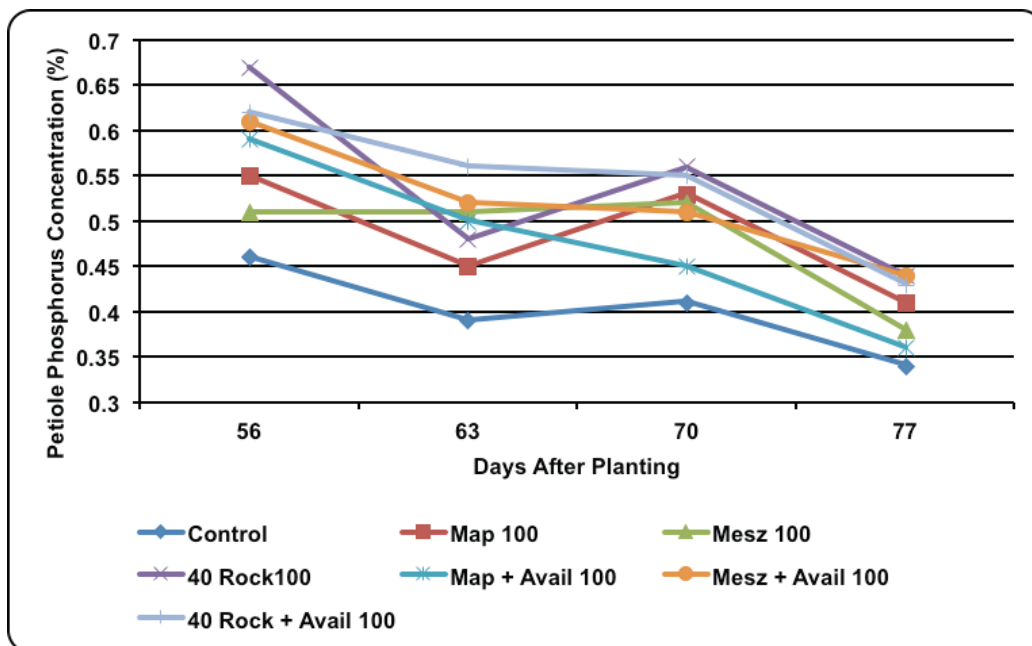


Figure 1c. Compares all fertilizer sources applied at 100 lbs P₂O₅/ac.

Figure 1d

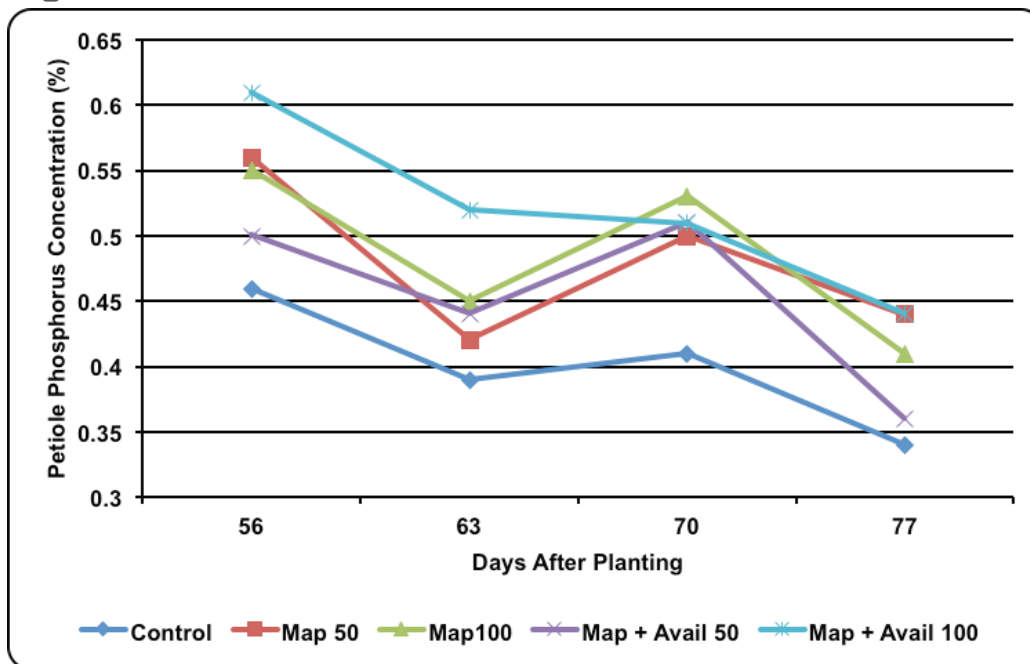


Figure 1d. Compares all fertilizer sources and rates containing MAP.

Figure 1e

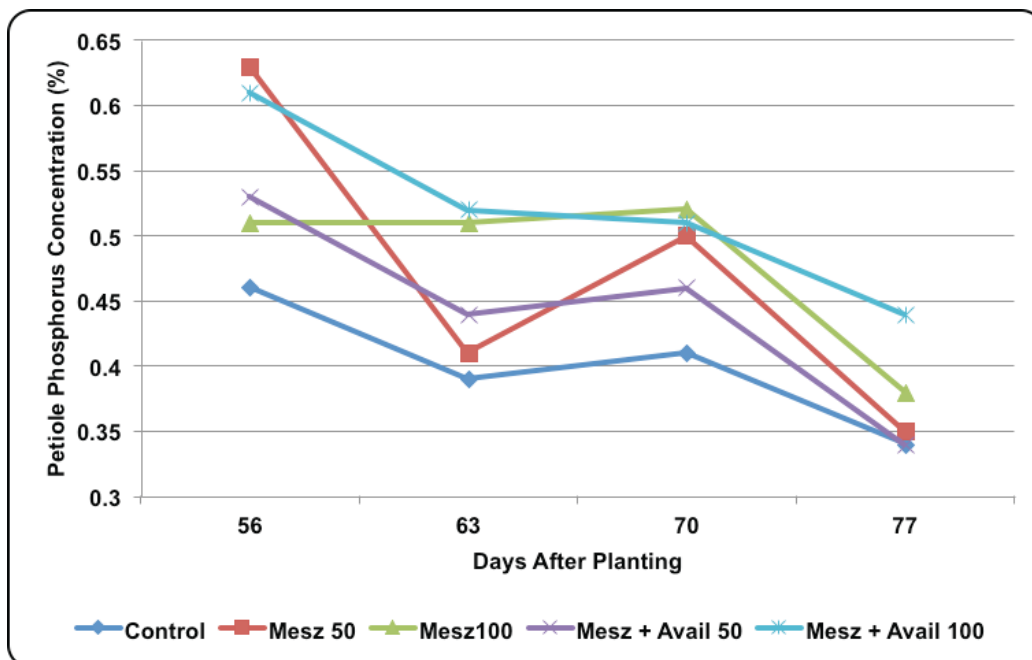


Figure 1e. Compares all fertilizer sources and rates containing MESZ.

Figure 1f

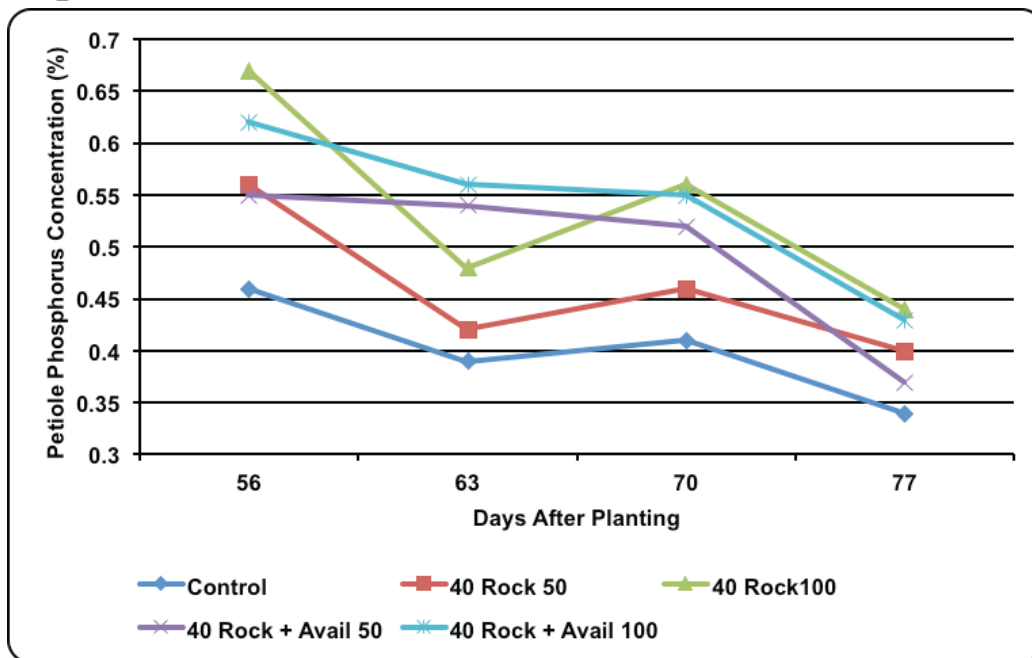


Figure 1f. Compares all fertilizer sources and rates containing 40 ROCK.

Figure 1g

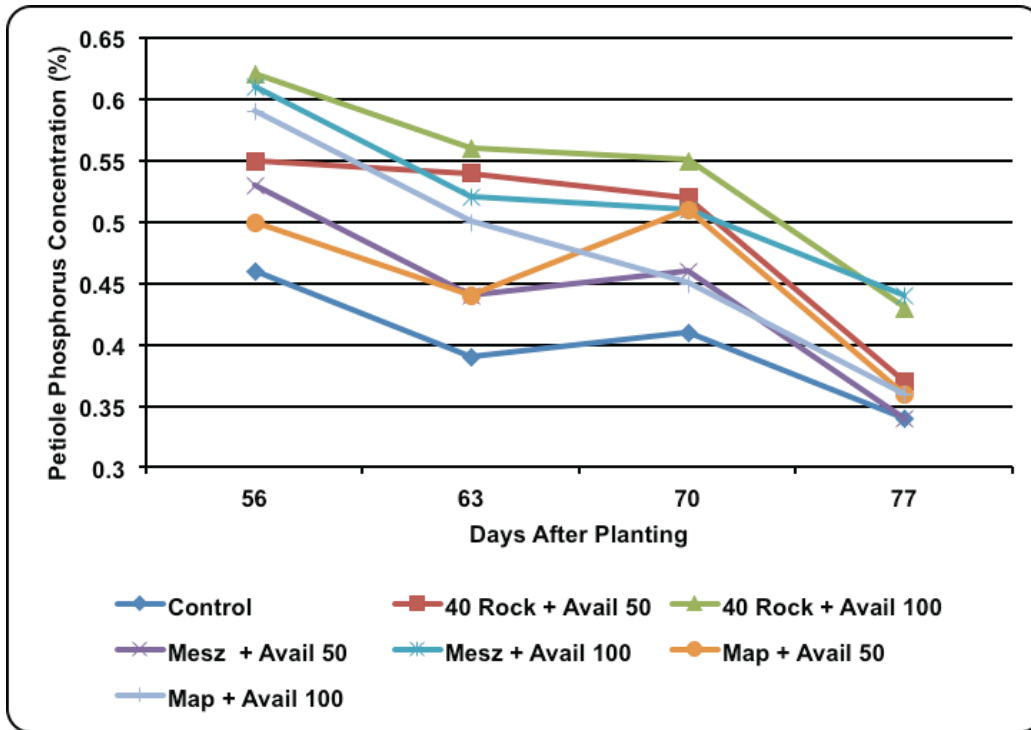


Figure 1g. Compares all fertilizer sources and rates containing AVAIL.

Figure 1h

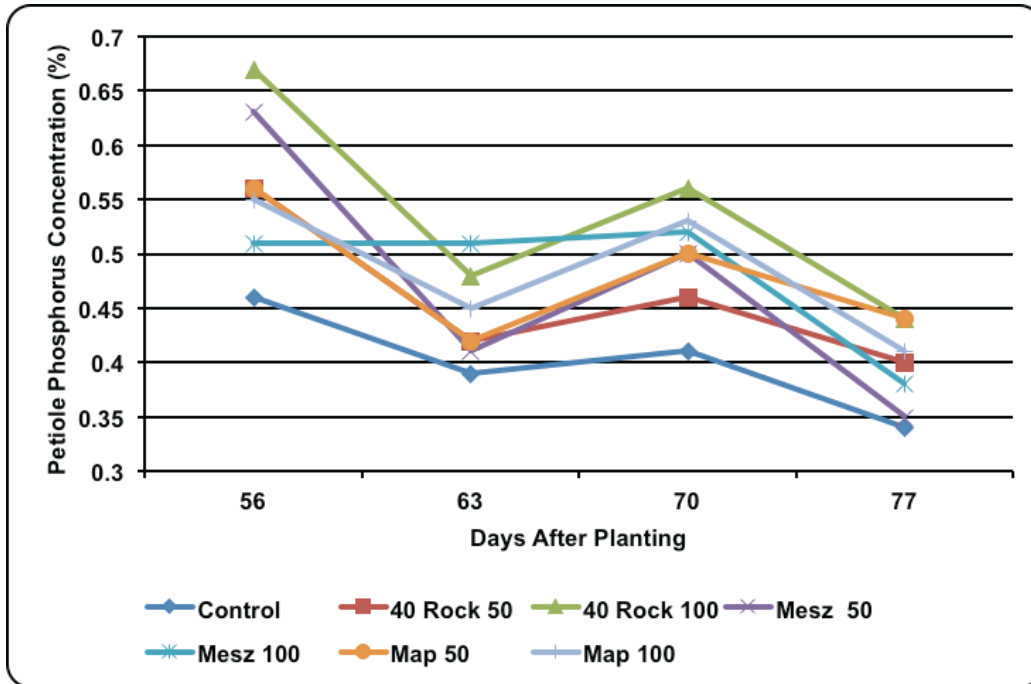


Figure 1h. Compares all fertilizer sources and rates with no AVAIL.

Total Plant Phosphorus Concentration

Source and rate of P fertilizer application did influence total plant P concentration in this study. Among the 13 treatments compared, MAP 100 and MESZ + AVAIL 100 showed the highest total plant P concentration. The next highest total P concentration was observed in plants that received MAP 50, MESZ 100, 40 ROCK 50, and 40 ROCK 100 (Fig. 2a).

For all P fertilizer sources applied at the rate of 50 lbs P_2O_5 /ac, plants that received MAP 50 and 40 ROCK 50 showed the highest total plant P concentration (Fig. 2b). For all P fertilizer sources applied at 100 lbs P_2O_5 /ac, it was observed that plants that received MAP 100 and MESZ + AVAIL 100 showed the highest total plant P concentration (Fig. 2c). When all sources and rates of P fertilizer containing AVAIL were compared to each other, plants that received MESZ + AVAIL 100 showed the highest total plant P concentration, followed by ROCK + AVAIL 100 and MAP + AVAIL 100 (Fig. 2d). A comparison of sources and rates of all fertilizer with no AVAIL added showed that plants that received MAP 100 had the highest total plant P concentration (Fig. 2e).

MAP 100 showed the highest total plant P concentration among all sources and rates containing MAP. MESZ + AVAIL 100 showed the highest concentration of total plant P among all sources and rates containing MESZ. 40 ROCK 50 and 40 ROCK 100 increased total plant P concentration among all sources and rates of P fertilizer containing 40 ROCK (Fig. 2a).

Figure 2. Effect of source and rate of phosphorus fertilizer application on total plant P concentration of Rio Grande Russet potato, 2013.

Figure 2a

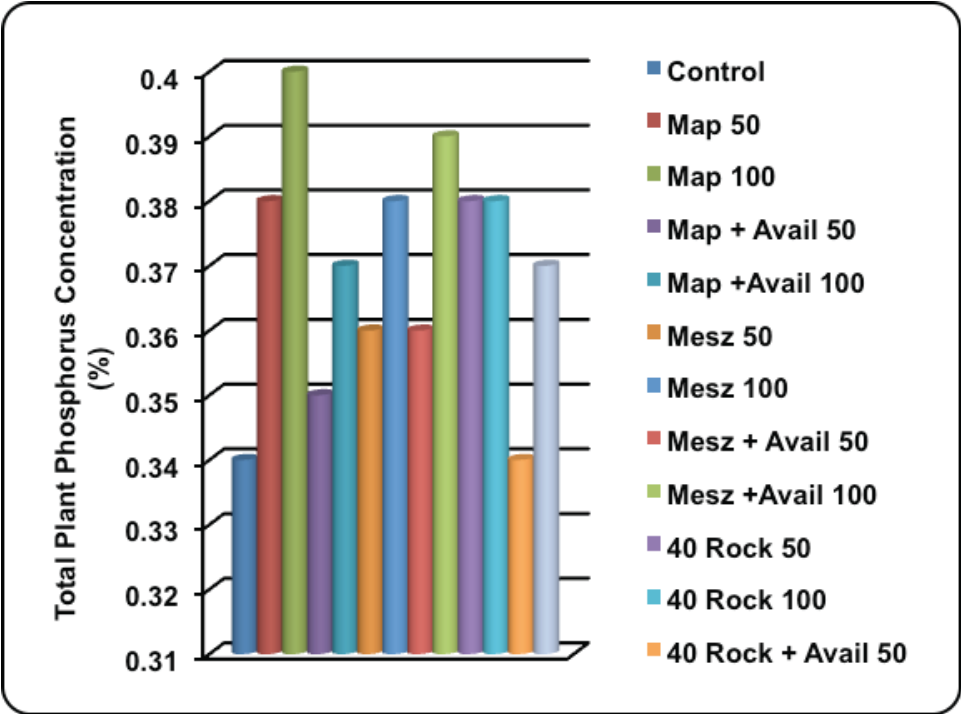


Figure 2a. Compares all sources and rates of P fertilizer.

Figure 2b

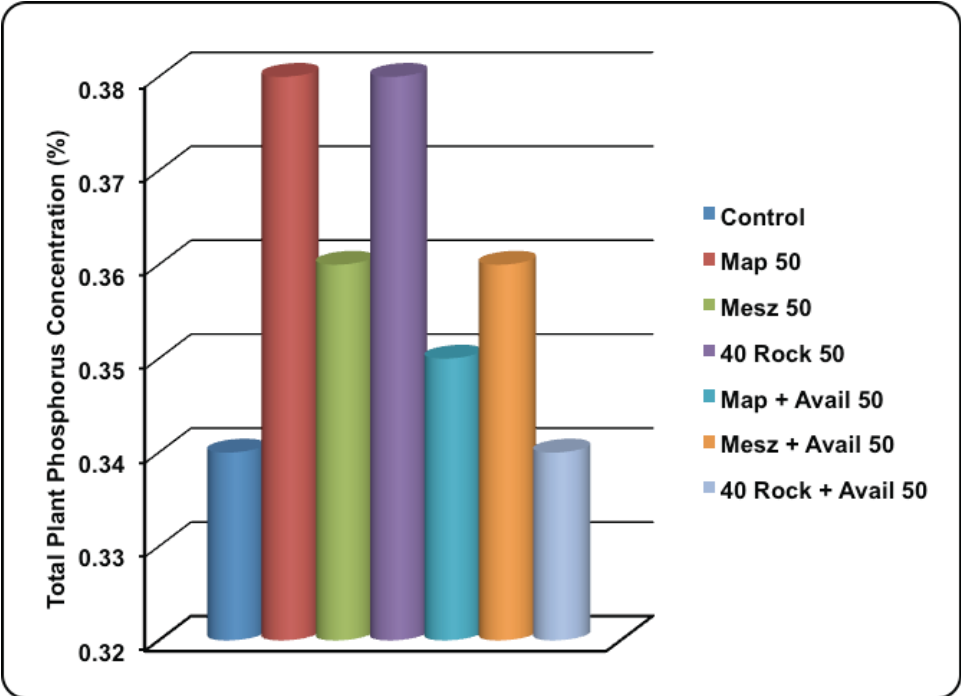


Figure 2b. Compares all fertilizer sources applied at 50 lbs P₂O₅/ac.

Figure 2c

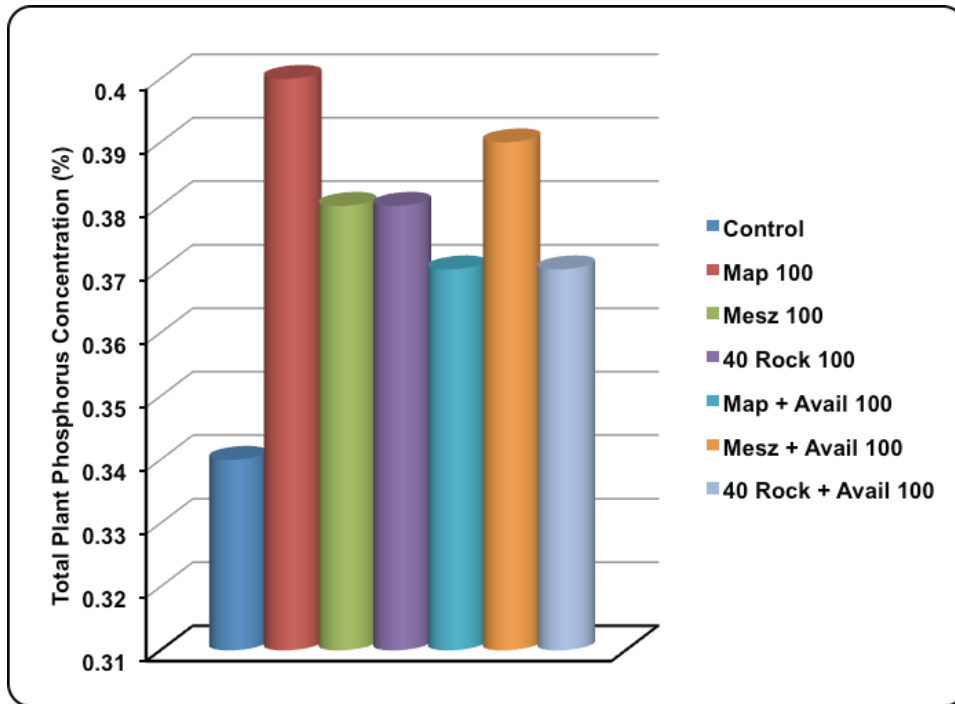


Figure 2c. Compares all fertilizer sources applied at 100 lbs P_2O_5 /ac.

Figure 2d

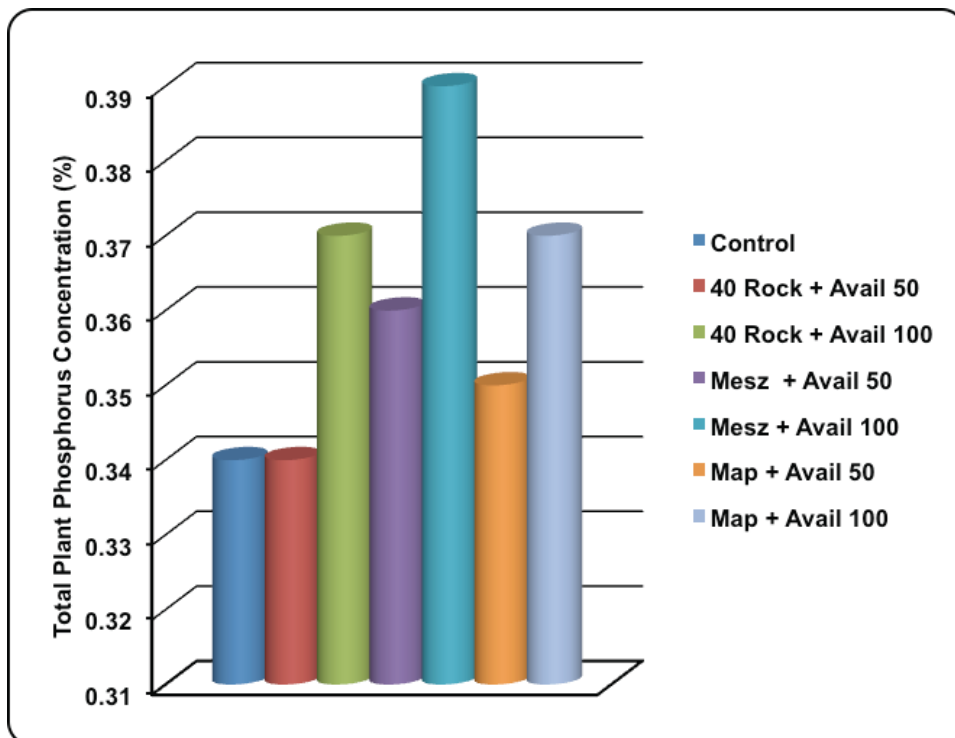


Figure 2d. Compares all fertilizer sources and rates containing AVAIL.

Figure 2e

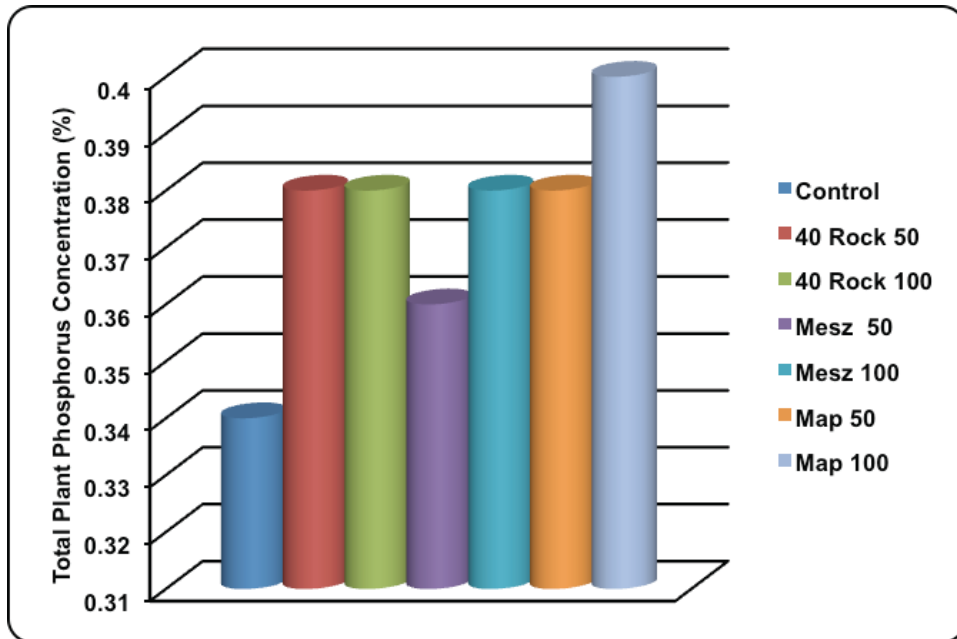


Figure 2e. Compares all fertilizer sources and rates with no AVAIL added.

Tuber Yield and Tuber Size Distribution

In this study, only the medium-size (4–10 oz) tuber distribution group responded to source and rate of P fertilizer application. MAP + AVAIL 100, MESZ 50, MESZ + AVAIL 50, and 40 ROCK + AVAIL 100 increased medium size tuber yield by 16%, 15.7%, 15%, and 12%, respectively (Table 1). Phosphorus uptake was high for all the fertilizer treatments, as evidenced by the high petiole and total plant P concentrations. However, the high P uptake did not increase total tuber yield or the yield of most of the tuber size distribution groups. This could be due to luxury consumption of P by the plant. In that case the soil had enough residual P supply for optimum production of Rio Grande Russet potato. Any additional supply and uptake of P by the plant either reduced yield or did not influence total yield and the yield of most tuber size groups (Table 1). It should be emphasized, however, that any luxury consumption of P by the potato plant from the application of MAP + AVAIL 100, MESZ 50, MESZ + AVAIL 50, and 40 ROCK + AVAIL 100 did increase the yield of medium-size (4–10 oz) tubers.

In this study, the residual soil P before any P fertilizer was applied was observed to be 199 lbs per acre P. This was equivalent to 179 lbs P₂O₅/ac.

Table 1. Yield response of Rio Grande Russet potato to source and rate of phosphorus fertilizer application, 2013.

Source and Rate of P Application (lbs/ac)	4–10oz	10–16oz	Total
Yield (cwt/ac)			
Control	267d	66a	467a ¹
MAP 50	284bcd	33f	464a
MAP 100	285abcd	43cdef	484a
MAP + AVAIL 50	291abcd	61ab	474a
MAP + AVAIL 100	310a	29f	482a
MESZ 50	309ab	37def	490a
MESZ 100	279d	52abcd	478a
MESZ + AVAIL 50	307ab	33f	483a
MESZ + AVAIL 100	274d	57abc	477a
40 ROCK 50	285abcd	52abcd	462a
40 ROCK 100	284abcd	35ef	464a
40 ROCK + AVAIL 50	277d	57abc	469a
40 ROCK + AVAIL 100	300abc	44bcdef	474a
LSD (0.05)	25	17	29
CV (%)	6	26	4

¹Figures in the same column and bearing the same letters are not significantly different at the 0.05 level of probability.

Tuber Quality

Tubers harvested from the control, MESZ 50, MESZ 100, and MESZ + AVAIL 100 plots showed the highest percentage of external defects (growth cracks, knobs, and misshapes) on the tubers when compared to all other treatments (Fig. 3a). Tubers harvested from plots that received MAP + AVAIL 100, MESZ + AVAIL 50, and 40 ROCK 50 P fertilizer showed the lowest percentage of tuber external defects (Fig. 3a).

The evaluation of tuber internal defects (hollow heart and brown center) indicated that tubers harvested from plots that received MESZ 50 and 40 ROCK + AVAIL 50 P fertilizer did not show any internal defects (Fig. 3b). Tubers harvested from plots that received MAP + AVAIL 50 and 40 ROCK 50 P fertilizer application showed the highest percentage of tuber internal defects (Fig. 3b).

In this study, source and rate of P fertilizer application did influence tuber specific gravity. Specific gravity was highest for tubers harvested from plots that received MAP 50, MAP + AVAIL 50, MAP + AVAIL 100, MESZ 100, 40 ROCK 50, and 40 ROCK + AVAIL 50 P fertilizer applications. Tubers from the control treatment also showed high specific gravity (Fig. 3c).

Figure 3a

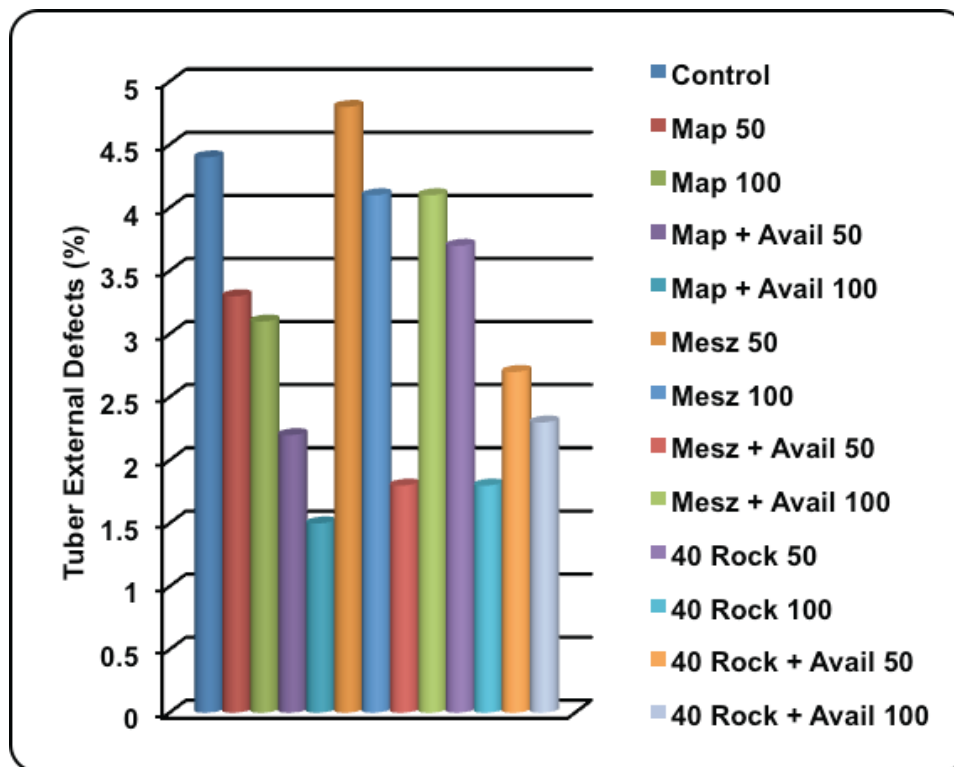


Figure 3a. Effect of source and rate of phosphorus fertilizer application on tuber external defects of Rio Grande Russet potato, 2013.

Figure 3b

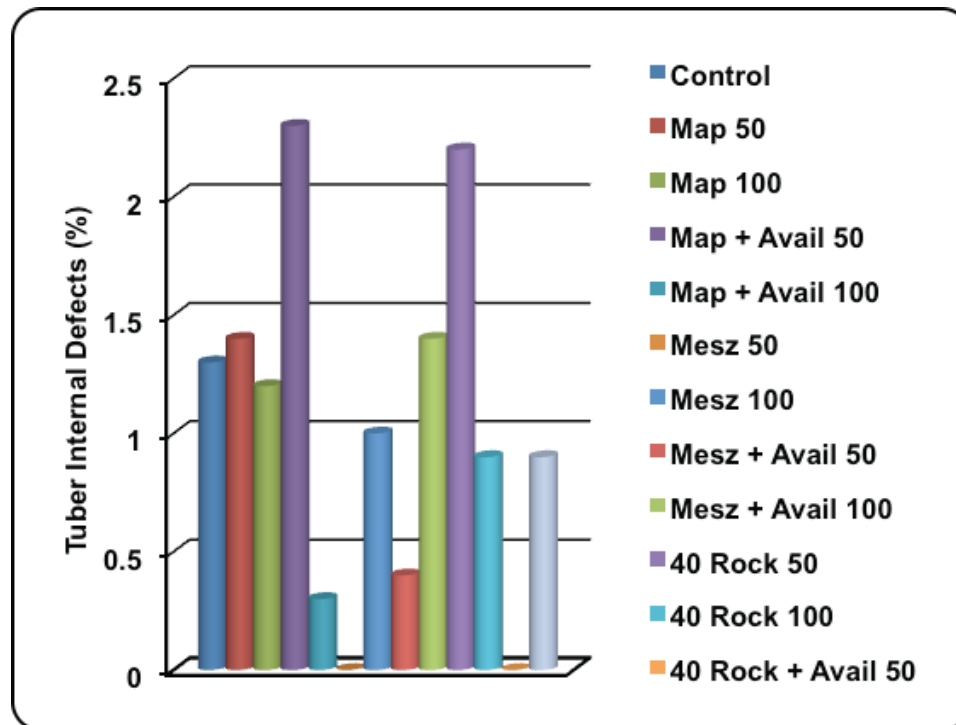


Figure 3b. Effect of source and rate of phosphorus fertilizer application on tuber internal defects of Rio Grande Russet potato, 2013.

Figure 3c

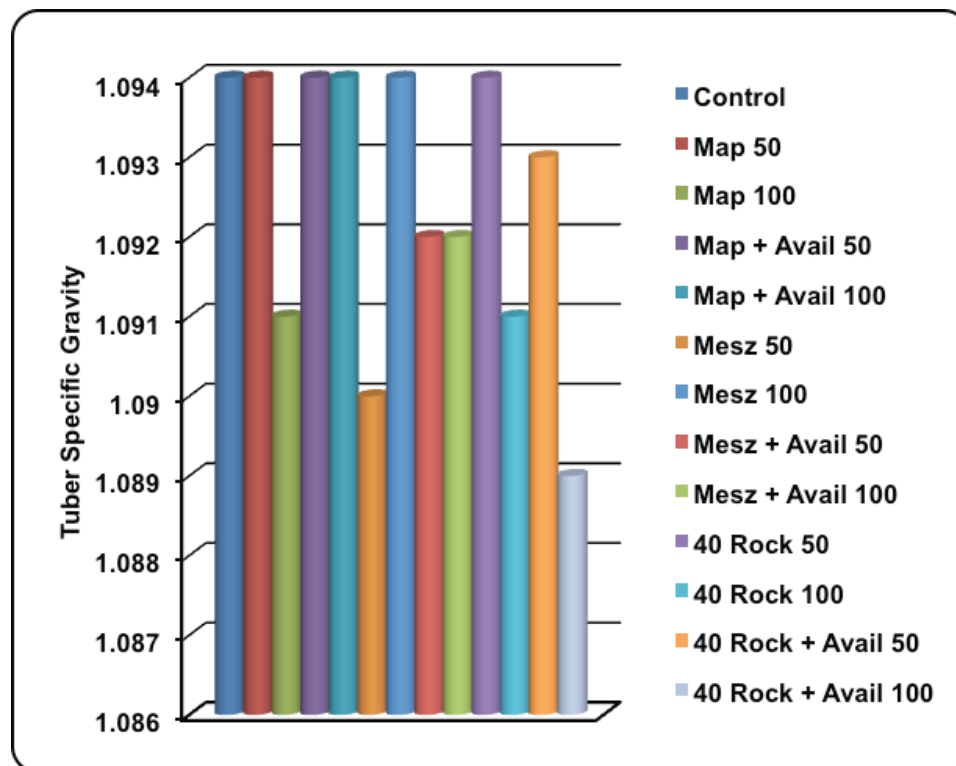


Figure 3c. Effect of source and rate of phosphorus fertilizer application on tuber specific gravity of Rio Grande Russet potato, 2013.

Summary

The purpose of this study was to evaluate the effect of the source and rate of P fertilizer application on plant phosphorus uptake as evidenced by petiole P and total plant P concentration of Rio Grande Russet potato. The effect of the source and rate of P fertilizer application on tuber yield, tuber size distribution, and quality was also evaluated.

Petiole P concentration was observed to be highest in potato plants that received 40 ROCK 100 and 40 ROCK + AVAIL 100 as sources and rates of P fertilizer, when compared to all other treatments.

Total plant P concentration was observed to be highest in plants that received MAP 100 and MESZ + AVAIL 100 as sources and rates of P fertilizer. The next highest total plant P concentration was observed in plants that received MAP 50, MESZ 100, 40 ROCK 50, and 40 ROCK 100 as sources and rates of P fertilizer.

The application of MAP + AVAIL 100, MESZ 50, MESZ + AVAIL 50, and 40 ROCK + AVAIL 100 did increase medium-size tuber yield by 16%, 15.7%, 15%, and 12%, respectively.

Tubers harvested from MAP + AVAIL 100, MESZ + AVAIL 50, and 40 ROCK 50 treated plots showed very minimal tuber external defects.

Tubers harvested from MESZ 50 and 40 ROCK + AVAIL 50 treated plots showed no tuber internal defects.

Specific gravity was highest for tubers harvested from plots that received MAP 50, MAP + AVAIL 50, MAP + AVAIL 100, MESZ 100, 40 ROCK 50, and 40 ROCK + AVAIL 50 as sources and rates of P fertilizer. Tubers from the control treatment also did show high specific gravity.



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