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Phosphorus Fertilization for Potatoes in West Texas

Abstract

Regional soil types and West Texas's hot, dry climate create a challenging environment for potato production by limiting phosphorus (P) availability. Soil phosphorus availability plays a significant role in plant growth and tuber development. This study evaluated potato productivity and nutrient dynamics across three P fertilizer application rates, compared with an unfertilized control. The addition of 35 lb P_2O_5 acre^{-1} significantly increased potato tuber yield compared to the untreated control, though there were no yield differences among the P rates tested. Findings support that correct phosphorus fertilization directly enhances potato P as well as nitrogen uptake and overall productivity, whereas rates exceeding production potential are not justified by the crop response, representing greater economic and environmental risk.

Keywords: Potatoes, phosphorus, nitrogen, tuber yield

Introduction

Phosphorus is an essential macronutrient for potatoes and plays a critical role in plant growth and development. Adequate phosphorus is important for root development, tuber initiation, and efficient nutrient uptake. When phosphorus is sufficient, potatoes develop stronger root systems that improve water uptake from the soil and increase water use efficiency. These stronger root systems also help reduce susceptibility to environmental stresses such as heat and drought, which are common in semi-arid regions like West Texas. Phosphorus management is especially important in this region because cultivated soils often have low phosphorus availability due to high soil pH, and potatoes have low phosphorous-use efficiency (Jasim et al., 2020). Limited phosphorus supply results in stunting (Blaylock et al., 2025), slow plant growth, weak root systems, delayed tuber formation, uneven tuber set, reduced tuber size, and overall poor crop performance.

Monoammonium phosphate (MAP) and Diammonium phosphate (DAP) are common commercial fertilizer sources of phosphorus. The phosphorus cycle involves biological and chemical processes that regulate phosphorus transformation, availability and fate (Figure 1). Phosphorus is immobile compared to nitrogen, which can freely move with water in the soil. Once applied, phosphorus availability can be affected by reactions with other soil minerals. Plants absorb phosphorus in the form of orthophosphate ions ($H_2PO_4^-$ and $H_2PO_4^{2-}$) (Johnson 2020). However, during soil solution transformation, the availability of these forms is influenced by soil pH (optimum range: 6.0-7.0: Sharma et al., 2017), mineral composition and other soil properties. Phosphorus may precipitate with calcium and magnesium, forming insoluble compounds in alkaline soils, including those in West Texas. Phosphorus can also be adsorbed by iron and aluminum, which influence its availability to potatoes in acidic soils. As the phosphorus pool is replenished by mineralization of organic matter or manure, phosphorus can also be tied up (or immobilized) in crop residues and in soil microbial biomass (Figure 1). These complex interactions and processes highlight the challenges in maintaining sufficient phosphorus availability to potatoes.

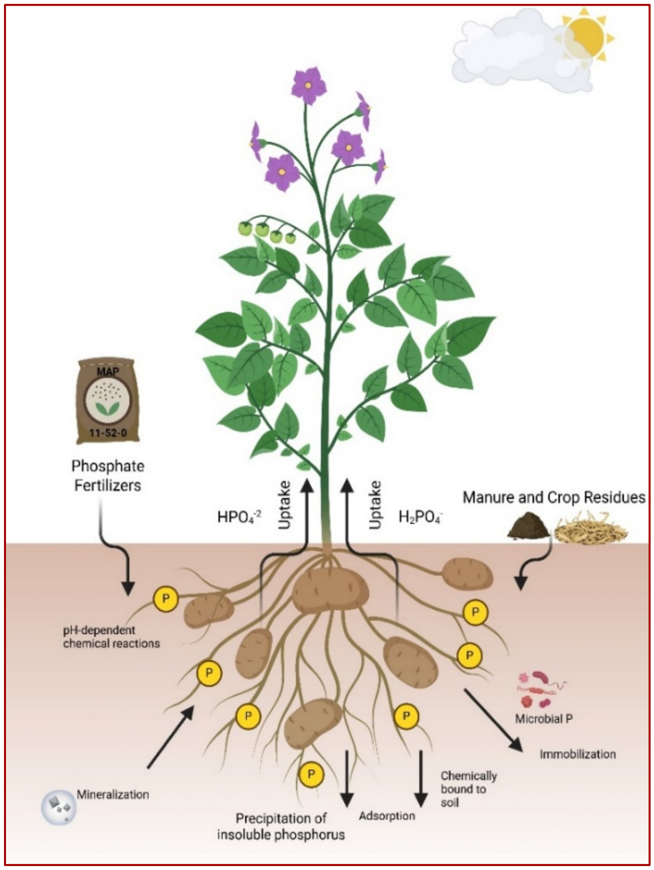

Figure 1: Phosphorus dynamics and movement from fertilizer to a potato plant (Adapted: BioRender).

Material and Methods

Field Experiment

To evaluate phosphorus management for potatoes in West Texas, a field research trial (Figure 2) was conducted at the Angelo State University Management, Instruction, and Research Center in San Angelo, TX. The soil at the experimental site is classified as a clay loam with pH 7.7 and alluvium-limestone parent material. Preplant soil analysis indicated 2.0% organic matter, 4.8 ppm nitrate, 12 ppm phosphorus and 478 ppm potassium. Yukon Gold, a popular potato variety recommended for West Texas (Matocha et al., 2009) and known for its thin, smooth, golden skin and yellow flesh, was used in this assessment. The experiment was arranged in a randomized complete block design with four replications, and potatoes were planted on February 14, 2025, maintaining a plant-to-plant distance of 12 inches. Experimental treatments included phosphorus fertilizer application rates and a control receiving no phosphorus fertilizer. Monoammonium phosphate (MAP) (11-52-0) was applied at rates of 35, 55 and 75 lb P_2O_5 acre^{-1} (67, 106 and 144 lb MAP acre^{-1}, respectively). All the phosphorus fertilizer was applied prior to planting in an 8×4 ft plot having two rows of potatoes on 24-inch spacing. Urea (46-0-0) was added to maintain equal nitrogen (N) input of 300 lb. N acre^{-1} across treatments. 43 lb. acre^{-1} nitrogen fertilizer was added at planting, and the remainder split among four equal applications in April and May. A sprinkler irrigation system was installed, and the experiment was irrigated frequently to avoid water stress. Herbicides pendimethalin (Prowl H_2O) and s-metolachlor (Dual Magnum) were applied at 32 and 16 oz ac^{-1}, respectively, at planting to control annual weeds. Perennial weeds (nightshade) were manually removed to avoid competition between crops and weeds for applied phosphorus treatments. Pesticide Zeta-cypermethrin (Mustang Maxx) was applied at 3 oz ac^{-1} to control insects and pests.

Figure 2: Potatoes growing in clay loam soil in West Texas (left) and potato plant with tubers at harvest (right).

Data Collection and Analysis

Potatoes were manually harvested on June 13. Three plants were removed per plot, and vines and tubers were separated for dry-matter determination and nutrient analysis. Tubers were washed to remove soil, then cut into smaller pieces. All samples were oven-dried at 150 °F until a constant weight was achieved. Remaining plants in all plots were harvested to determine potato yields. Soil was sampled (12-in depth) from 6 spots in each plot to obtain a composite soil sample to determine post-harvest soil P. Dried plant and soil samples were ground to pass through a 1-mm sieve and were analyzed for nutrient content. Measured responses were analyzed in SAS 9.4 using mixed models treating phosphorus application rate as a fixed effect, and block as a random effect. Some variation in ultimate plant establishment occurred among plots, so the number of plants per plot was treated as a covariate in the analyses. Significant differences were identified at $\alpha \leq 0.05$ and means were separated using Fisher's Protected LSD.

Results and Discussion

Potato Performance

Unlike controlled-environment research, this trial accounted for local soil variability, climatic conditions, and typical management practices. Conducting the research trial under local conditions ensures that the results are applicable to West Texas potato growers. During the potato-growing season, mean maximum and minimum air temperatures ranged from 25 to 104 °F and from 12 to 78 °F, respectively (San Angelo Weather Forecast Office (WFO): 2025). Whereas the experiment received 9.2 inches of total rainfall (Texas A&M AgriLife Center – San Angelo). Phosphorus application rate significantly ($p < 0.001$) affected tuber yield, vine dry matter, P content in vines and tubers, total P uptake, tuber N content, tuber N uptake, and total N uptake. However, phosphorus concentration in vines and tubers and soil residual P concentration, along with vine and tuber N concentration and soil residual nitrate concentration, were not influenced. These specific effects are described in the following sections.

Tuber Yield

Potato tuber yield in all phosphorus-fertilized plots was significantly (*p <0.001*) higher compared to the unfertilized control (Figure 3A). Tuber yield at 35 lb. P_2O_5 acre^{-1} was 90% higher compared to the unfertilized control. Tuber yield response to added phosphorus fertilizer aligns with recent research of Rutan and Steinke (2026) who observed the yield response under deficient, optimal and sufficient soil test phosphorus. Interestingly, no significant differences were observed among phosphorus fertilizer application treatments of 35, 55 and 75 lb. P_2O_5 acre^{-1}. Regression analysis indicated that the tuber yield plateau was achieved at 53 lb. P_2O_5 acre^{-1} (Figure 3B). This suggests that a moderate phosphorus application at 35 lb. P_2O_5 acre^{-1} was sufficient to meet the crop phosphorus requirements in this season. These results are consistent with previous research as potato yield has been shown to be unresponsive to increasing phosphorus application rates in high pH soils (Jasim et al., 2020).

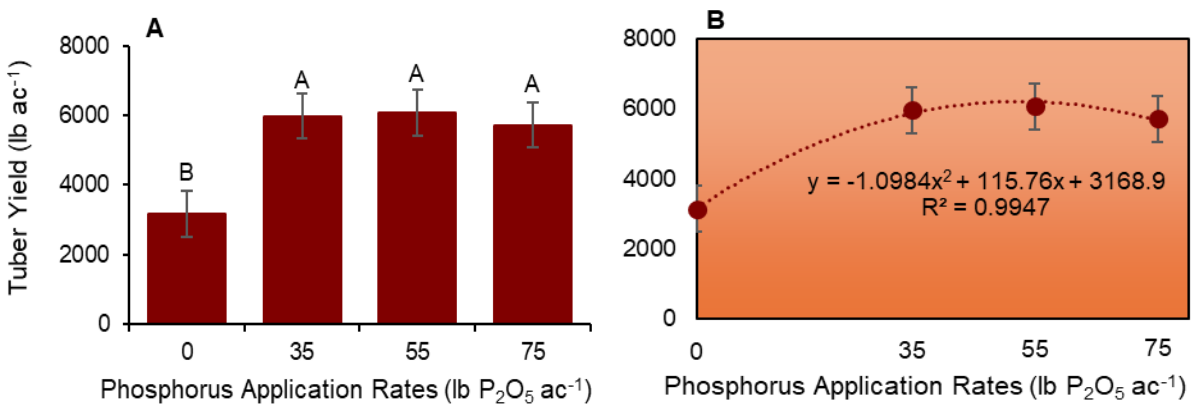

Figure 3: Effect of phosphorus application rates on tuber yield (A) and regression relationship between phosphorus application rates and tuber yield (B) of Yukon Gold potatoes.

Vine Dry Matter

Vine dry matter is a critical indicator of above-ground plant growth and overall plant development. We found that phosphorus application significantly (*p <0.001*) increased vine dry matter (Figure 4). Vine dry matter at 35, 55 and 75 lb. P_2O_5 acre^{-1} was 56, 91 and 89% higher, respectively, than the unfertilized control. Similar to tuber yield, no significant differences were observed among phosphorus fertilizer rates of 35, 55 and 75 lb. P_2O_5 acre^{-1}. However, a considerable increase in vine dry matter suggests greater vegetative growth than tuber development. While robust vines contribute to greater photosynthetic capacity that supports tuber development, the efficient translocation of photosynthates from vines to tubers remains a critical factor. Surplus phosphorus, along with sufficient nitrogen supply, may prolong vine growth and delay assimilate partitioning, leading to decreased proportional gains in tuber yields.

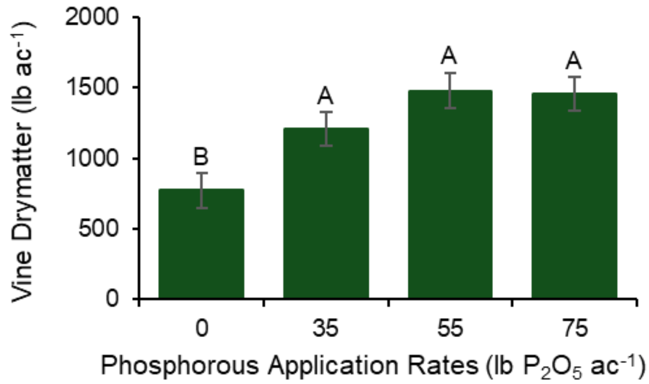

Figure 4: Effect of phosphorus application rates on vine dry matter of Yukon Gold potatoes.

Phosphorus Uptake

Phosphorus fertilization significantly increased phosphorus uptake in both tubers (p = 0.0236) and total plant biomass (p = 0.0097) compared to unfertilized plots (Figure 5). In this study, an application rate of 35 lb P_2O_5 per acre was sufficient to achieve maximum uptake. Applying the correct fertilizer rate is important because both under- and over-application can result in economic or environmental losses. Rutan and Steinke (2026), reported that higher P_2O_5 in plant parts did not result in increased tuber yield. Similarly, excess phosphorus that is not taken up by the plant may accumulate in the soil or remain in plant tissue. These results indicate that optimal phosphorus management can help growers reduce input costs without sacrificing productivity.

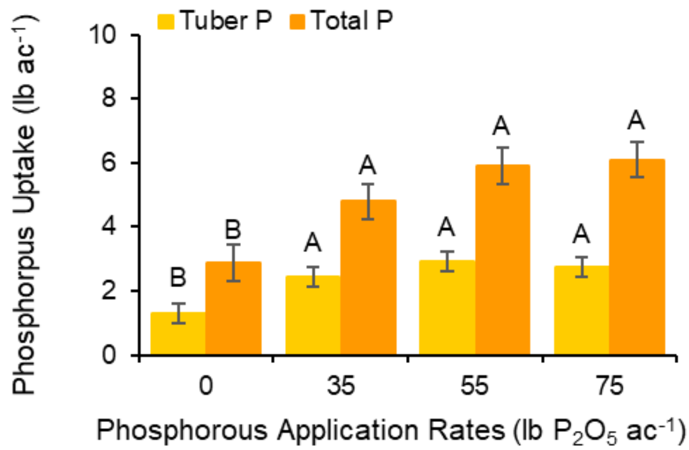

Figure 5: Effect of phosphorus fertilizer application rates on tuber and total phosphorus uptake in Yukon Gold potatoes.

Phosphorus – Nitrogen Synergy

Nitrogen is a key element in plant growth, and nitrogen deficiency can cause severe yield losses. In this study, potatoes received sufficient nitrogen in all phosphorus treatments. We also measured nitrogen uptake to better understand the overall nutrient dynamics and crop performance. Results showed that nitrogen uptake improved in all phosphorus-fertilized treatments compared to the control. This response aligns with the well-known synergistic interaction between nitrogen and phosphorus, where phosphorus promotes root development, which in turn promotes the plant's ability to absorb nitrogen efficiently. Nitrogen fertilization in potato production is the most expensive; therefore, this interaction is important for growers, as the results indicated that when phosphorus nutrition was optimal, nitrogen uptake in potatoes also increased. These findings suggest that phosphorus management not only directly improved potato growth and tuber yield but also supported efficient nitrogen use.

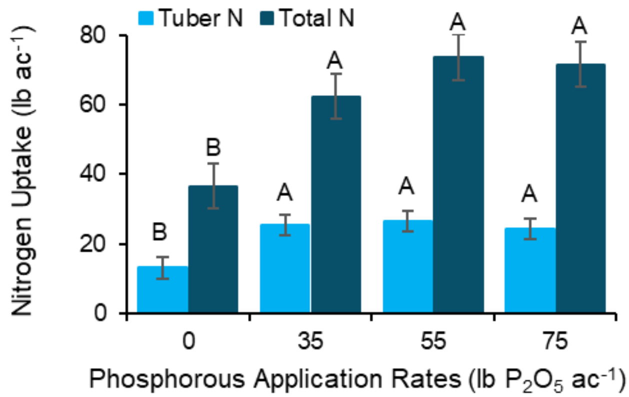

Figure 6: Tuber and total plant nitrogen uptake under different phosphorus fertilizer application rates.

Practical Recommendations

Results presented in this study are based on single growing season and site-specific conditions typical of West Texas. To authors knowledge, information is limited on phosphorus management for potatoes in West Texas. Literature cited in this assessment also includes studies from other potato growing regions to provide general context for our findings, however, site-specific conditions including soil variability and seasonal variations in temperature or rainfall may lead to different outcomes. Therefore, multi-location and multi-season studies with different varieties are recommended to validate the consistency of findings. Based on the findings from our trial consistent with the established literature on potato production, the following recommendations are suggested for potato (Yukon Gold) growers in West Texas:

Phosphorus Fertilization: Sufficient phosphorus should be validated with a soil test, and fertilizer should be applied before planting when growing potatoes in West Texas. Growers should band all the required phosphorus below the seed potatoes at planting. Although these findings informed of a yield plateau at 53 lb. P_2O_5 acre^{-1}, we recommend soil testing prior to planting to determine phosphorus availability and quantify the phosphorus rate needed. In this way, soil testing helps ensure no nutrient deficiencies for the crop and prevents over-application. If phosphorus deficiency symptoms are observed, plant tissue analysis can be performed to better understand crop nutrient availability and phosphorus dynamics during the growing season.

Balanced Fertilization: Balanced fertilization with nitrogen and potassium helps promote plant growth. As we observed in this study, sufficient and balanced phosphorus and nitrogen supply ensured enhanced nutrient uptake.

Irrigation: Potatoes are sensitive to water stress. Limited water supply negatively affects potato plant growth and nutrient availability. In this season, the maximum temperature reached 104 °F, whereas it is well known that if temperatures are over 90 °F, potato tuber numbers and size are affected (Roberts: accessed 2025). Often, high temperatures and dry conditions in West Texas can influence potato performance. Hilling is useful in this regard as it insulates the plants against extreme temperatures and drying. It is also recommended to avoid heavy clay soil for potato production. Depending on prevailing climatic conditions and soil, we suggest adequate irrigation for improved nutrient availability, heat stress mitigation, and crop yields.

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Conflicts of Interest

Authors declare no conflict of interest.

Literature Cited

Blaylock, A., Cowell, L., Howell, M., Wyant, K., and Fletcher, S. (2025). Potato Nutrient Management Guide. eKonomics Potato Crop Guide. Available online at: https://nutrien-ekonomics.com/agronomics/crop-guides/potato-nutrient-management-guide/. Accessed on: November 19, 2025.

Jasim, A., Sharma, L. K., Zaeen, A., Bali, S. K., Buzza, A., and Alyokhin, A. (2020). Potato Phosphorus Response in Soils with High Value of Phosphorus. Agriculture 10(7): 264. https://doi.org/10.3390/agriculture10070264

Johnson, S. (2020). Phosphorus: An Essential Element for Potatoes. Bulletin 2250. University of Maine Cooperative Extension Publications. Available online at: https://extension.umaine.edu/publications/2250e/. Accessed on: August 18, 2025.

Matocha, M., Anciso, J., and Black, M. (2009). Crop Profile for Potatoes in Texas. Available online at: https://ipmdata.ipmcenters.org/source_report.cfm?view=yes&sourceid=270. Accessed on: August 25, 2025.

Roberts, R.E. Texas Potatoes. Texas Agricultural Extension Service, Texas A&M University. Available online at: https://lubbock.tamu.edu/programs/crops/vegetables/texas-potatoes/. Accessed on: June 20, 2025.

Rutan, J. and Steinke, K. (2026). Potato Growth, Yield, and Quality in Response to Phosphorus Application Rates Across a Range of Soil Test P Concentrations. European Journal of Agronomy, 173: 127917. https://doi.org/10.1016/j.eja.2025.127917

Sharma, L.K., Bali, S.K., and Zaeen, A.A. (2017). A Case Study of Potential Reasons of Increased Soil Phosphorus Levels in the Northeast United States. Agronomy, 7(4): 85. https://doi.org/10.3390/agronomy7040085