NUTRIENT MANAGEMENT

Bryan G. Hopkins, Jeffrey C. Stark, Dale T. Westermann, and Jason W. Ellsworth

NUTRIENT MANAGEMENT EFFICIENCY

Nutrient Uptake Patterns

Potatoes require optimal levels of essential nutrients (link) throughout the growing season. Nutrient uptake rates are often slow early in the season, increase rapidly during the tuber bulking phase (link), and then slow as the plant matures (Fig. 8.2) (link). Potato plants take up nutrients in the range of several hundred pounds per acre to less than a tenth of a pound per acre (Table 1) (link).

Table 1. Potato nutrient uptake and removal totals based on a 400-500 cwt./acre yield.

Nutrient	Total Plant Uptake, lbs/acre	Amount in Tuber (Removal), lbs/acre
Nitrogen	200-240	
Phosphorus	25-35 (57-80 as P_2O_5)*	
Potassium	280-320 (336-384 as K_2O)*	
Sulfur	18-24	
Calcium	50	
Magnesium	40	
Zinc	0.11	
Manganese	0.9	
Iron	1.8	
Copper	0.09	
Boron	0.18	
Chloride	10	
Molybdenum	0.005	
Nickel	0.005	

*Quantities of phosphorus and potassium are expressed in fertilizer materials as P_2O_5 and K_2O, respectively. Neither of these compounds exist, but these are the forms that were thought to be taken up by plants in the days when fertilizer labeling was initiated in the 1940's. Although later proven to be non-existent, these expressions for phosphorus and potassium have remained entrenched as the convention for fertilizer labeling. (P x 2.29 = P_2O_5 and K x 1.2 = K_2O)

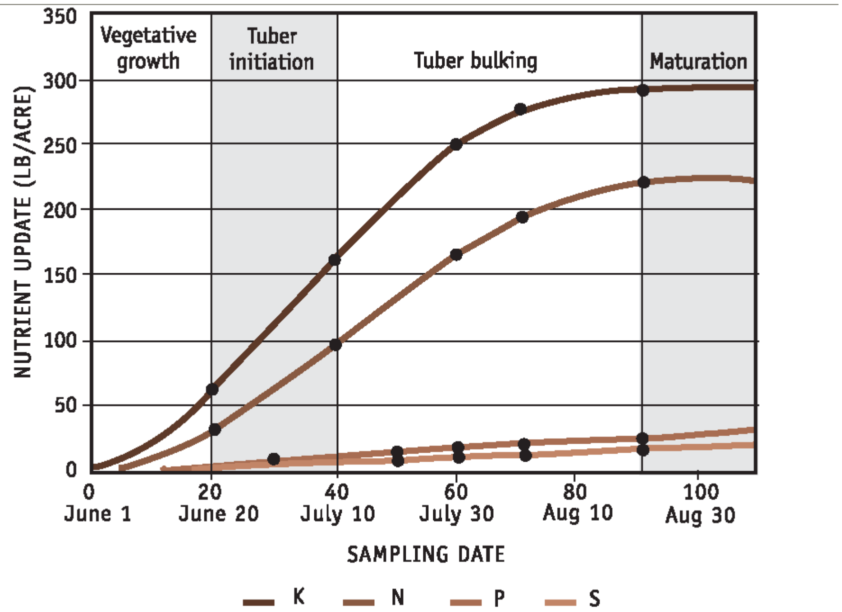

Figure 8.2. Total plant N, P, K, and S uptake by Russet Burbank potatoes for field tests near Aberdeen, Idaho, 1991–95.

Factors Affecting Nutrient Requirements

Potential Tuber Yield - Maturity class of the cultivar grown and the length of the growing season are the two primary factors affecting nutrient requirements. Early maturing cultivars, such as Russet Norkotah, have a relatively high nutrient demand through the vegetative and tuber initiation phases. Thus, a larger percentage of the nutrients need to be applied early in the season, especially in the case of nitrogen. Later maturity cultivars, such as Russet Burbank, have a relatively longer nutrient uptake period. (See variety section for nitrogen application recommendations for specific varieties.) (link) Length of growing season affects nutrient requirements, especially for the late maturing varieties. Adding one week of growth with an average bulking rate of 7 cwt./acre/day would result in 50 cwt./acre increase in yield and, as a result, a proportional increase in nutrient requirement.

Soil and Environmental Factors – **Restrictions** in root growth caused by hardpans, compaction, shallow soil, or dry subsurface conditions reduce the volume from which roots extract nutrients; resulting in a proportional increase in nutrient need in the soil explored. **Sandy soil** has low nutrient holding capacity and high leaching potential. Potatoes grown on sandy soil generally require a “spoon-fed” approach with relatively more of mobile nutrients such as nitrogen, sulfur, and chloride. **Soil pH** significantly affects the availability of many nutrients, especially phosphorus, zinc, manganese, iron, and copper. Availability of these nutrients greatly decreases as pH increases from the optimal 6.5-7.0 to alkaline conditions of pH 7.8-8.5. Alkaline soils are commonly **calcareous** (presence of lime minerals - calcium and magnesium carbonates). Lime minerals further reduce the availability of phosphorus and the micronutrients listed above. Acid soil pH of less than 6.0 is also known to reduce the availability of phosphorus. Low **soil temperatures** result in the slowing of biological processes and many chemical processes. As a result, root growth and subsequent access to immobile nutrients such as phosphorus is restricted. Microbial decomposition of organic materials is also slowed, resulting in reduced mineralization of nutrients such as nitrogen and sulfur. High soil and canopy temperatures result in increased growth rates and nutrient demands. **Pests** can also influence nutrient needs. Weeds compete for valuable nutrients. Insects, nematodes, and diseases can damage root tissue and result in a nutrient supply problem. They can also damage the vascular system responsible for transporting nutrients from below the soil surface to leaves.

ESSENTIAL NUTRIENTS

Plants require 17 essential nutrients (Table 12). Nutrients are delineated as either organic or inorganic elements. The organic elements required by plants include carbon, hydrogen, and oxygen. The organic elements make up the majority of the plant by weight and primarily come from the air and the water. The inorganic elements are further separated into macro- and micronutrients. Macronutrients include nitrogen, phosphorus, potassium, calcium, magnesium, and sulfur and are designated as such because they are needed in relatively large quantities by the plant and are most commonly deficient and applied as fertilizer as compared to micronutrients.

Table 1. Essential nutrients required for plant growth.

Nutrient	Form of Uptake	Amount in Plant Wet weight, %	Function in Plant
Carbon (C)	CO2, CO32-, or HCO3-		
Hydrogen (H)	mainly as H2O		
Oxygen (O)	mainly as H2O and O2		
Nitrogen (N)	NO3- or NH4+		
Phosphorus (P)	HPO42- or H2PO4-		
Potassium (K)	K+		
Calcium (Ca)	Ca2+		
Magnesium (Mg)	Mg2+		
Sulfur (S)	SO42-		
Zinc (Zn)	Zn2+		
Manganese (Mn)	Mn2+		
Iron (Fe)	Fe2+		
Copper (Cu)	Cu2+		
Boron (B)	BO43-		
Chloride (Cl)	Cl-		
Molybdenum (Mo)	MoO42-		
Nickel (Ni)	Ni2+		
Other Non-Essential Nutrients			
Sodium (Na)	Na+		
Silicia (Si)	Si4+		

Determining Nutrient Requirements

Soil Analysis

The accuracy of a soil test result can be affected by both the laboratory analysis and the quality of the soil sample. A soil sample that is not representative of the corresponding field area will likely be misleading and cause inappropriate fertilizer application rates. Therefore, it is essential that each field be sampled using procedures that represent the majority of the soils in the field. Preferably, areas with significant variations in soil texture, color, topography, and cropping and fertilization history should be sampled and fertilized separately from the rest of the field.

A composite soil sample for a field zone should consist of about 20 soil cores from the 0-12 inch soil depth using a soil probe that provides a uniform sample throughout the entire sampling depth. Each sample should represent no more than 20 acres, even if the soil appears uniform. Typically, the 20 cores are taken in a selectively random pattern such as a zigzag pattern throughout the sampling area. The samples should be thoroughly mixed together and a 2/3 pint subsample should be collected and immediately air dried before being sent to the lab. Keeping soil samples warm and moist will cause N mineralization to continue, leading to erroneously high soil test N concentrations.

Plant Tissue Analysis

In potatoes, the petiole of the fourth leaf from the top of the plant (Figure 7.2) is generally used to determine plant nutrient status. It is important to consistently sample the fourth petiole since analysis of samples taken from higher or lower leaf positions will produce significantly different results that are not calibrated with the crops nutritional status. Petiole sampling usually begins at tuber initiation and is continued on a weekly basis throughout most of the tuber growth period.

Usually 50-60 petioles are collected from representative areas of the field consistent with the soil sampling procedure. Alternatively, separate samples can be collected from selected areas or management zones differentiated by soil type, crop history, topography, etc. All leaflets should be stripped off the petiole immediately after sampling. The petioles should then be placed in a clean container or paper bag and quickly dried at 150 F or kept cool (<40 F) until submitted to the lab. This procedure should minimize changes in nutrient concentrations that can occur in warm, moist tissue samples.

Petiole nutrient concentrations are divided into low, marginal and sufficient ranges (Table 7.1), based on their relationship to growth and yield. These ranges can vary according to growth stage and cultivar, particularly for nitrate nitrogen concentrations which can vary widely over the course of the growing season. Sufficient concentrations are generally adequate for vine and tuber growth at the time of sampling. However trends observed from weekly petiole samples are more reliable in anticipating and detecting nutrient deficiencies.

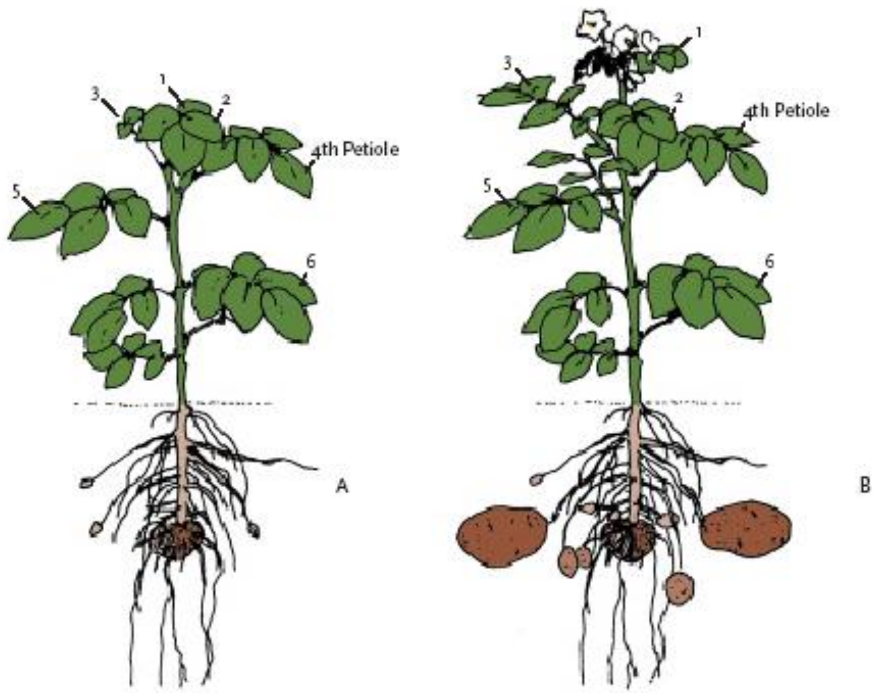

Figure 8.4. Diagrams of vegetative shoot with petioles (a) and full potato plant with a floral spike (b). The fourth petiole is used in tissue analyses for determining plant nutrient status.

Adapted with permission from Potato Health Management, 1993, Randall C. Rowe (ed.), Plant Health Management Series, the American Phytopathological Society, Eagan, MN, and adapted from R. E. Thorton and J. B. Sieczka, 1980, Commercial potato production in North America, American Potato Journal 57, supplement, Potato Association of America, Orono. ME.

Figure 7.2. Diagram of vegetative shoot with numbered petioles.

Table 7.1. Suggested ranges in nutrient concentrations for the fourth petiole of Russet Burbank potatoes during tuber bulking.

Nutrient	Low	Marginal	Sufficient
Nitrate nitrogen, ppm	<10,000	10,000-15,000	15,000-20,000
Phosphorus, %	<0.17	0.17-0.22	>0.22
Potassium, %	<7.0	7.0-8.0	>8.0
Calcium, %	<0.4	0.4-0.6	>0.6
Magnesium, %	<0.15	0.15-0.3	>0.3
Sulfur, %	<0.15	0.15-0.2	>0.2
Zinc, ppm	<10	10-20	>20
Manganese, ppm	<20	20-40	>40
Iron, ppm	<20	20-50	>50
Copper, ppm	<2	2-4	>4
Boron, ppm	<10	10-20	>20

Fertilizer Application Methods

Fertilizer application methods commonly used for potatoes include:
1) preplant broadcasting followed by incorporation,
2) banding at markout or planting,
3) side-dressing after planting,
4) applying foliar nutrient sprays,
5) injecting liquid fertilizer through the irrigation system.

Broadcast fertilizer applications made in the fall or spring should be incorporated into the surface 6-12 inches of soil to provide ready access for the potato roots. Usually, less than half of the seasonal N supply should be applied prior to planting, but the bulk of all other fertilizers can be broadcast at this time. Preplant applications can largely eliminate the need for additional applications at planting, allowing more time for management of the planting operation.

Fertilizers can be banded at markout or at planting. The bands should be placed close enough to the seed piece to provide early root access. However, direct contact with the seed piece should be avoided, particularly with high fertilizer rates or fertilizers with high salt index values. For markout applications, an effective band placement is 3-4 inches to the side of the seed piece and 1-2 inches below seed piece depth. Fertilizer bands applied at planting are best placed 1 to 2 inches above seed piece depth to provide greater early-season availability to the developing plant. Liquid formulations including N and P along with micronutrients are commonly applied in bands to enhance early season availability.

Side-dressed N fertilizer is often applied during vegetative growth prior to tuber initiation. This method is particularly effective on sandy soils that are prone to nitrate leaching. Later applications risk damage to the crop from root pruning that can occur during the side-dressing operation. Side-dressing of other nutrients is usually not as effective as broadcast or band applications.

Foliar nutrient sprays can be effective in treating existing or developing nutrient deficiencies and usually produce a quicker response than soil applications. This is particularly true for elements such as iron, zinc, manganese, copper and boron. Tank-mixing surfactants usually improves nutrient absorption through the leaf surfaces. However, the amount of any nutrient that can be safely applied is limited because concentrated sprays can cause leaf damage.

Water-soluble fertilizers are commonly applied through sprinkler irrigation systems in southern Idaho. Nutrients such as nitrogen, phosphorus, potassium and sulfur can be applied according to the needs of the crop and partially incorporated into the root zone with the irrigation water. Careful irrigation management is essential when using fertigation because of the high potential for nutrient leaching and runoff when irrigation rates are excessive. The compatibility of the fertilizer materials with the irrigation water should be checked beforehand since precipitation of nutrients can reduce availability and clog nozzles. Uniformity of water application also has a significant effect of the efficiency of water-run fertilizer.

Nitrogen Management

Crop Nitrogen Uptake

Total N uptake for potato crops in southern Idaho usually ranges from about 150 to 250 lb N/acre, depending on cultivar and yield potential. At harvest, about 60-65% of the total plant N is contained in the tubers, while about 30% remains in the vines. During tuber bulking, potato plants require about 2.0 to 3.0 lb N/acre/day depending on tuber growth rate.

About 60% of the seasonal N requirement is taken up by 75 days after planting. Consequently, adequate N must be available to the crop early in the season to allow for sufficient canopy development. Research shows that about 150-180 lb N/acre from soil and fertilizer sources is required by the time the rows begin to close to provide for optimum canopy development and yield. However, excessive N availability prior to tuber initiation can delay tuber bulking by up to 2-3 weeks, reducing tuber yields by as much as 80-120 cwt/acre. Excessive early-season N can also increase the susceptibility to brown center and hollow heart. Excessive late-season N applications usually reduce specific gravity and skin set, and increase the potential for nitrate leaching.

Available Nitrogen Sources

Crops can acquire N from a number of sources including (1) the inorganic soil N forms nitrate (NO_3) and ammonium (NH_4), (2) N mineralized from soil organic matter, crop residues and animal wastes (3) N present in the irrigation water, and (4) fertilizers.

Nitrogen Fertilizer Recommendations

The recommended rates are based on the total N requirement adjusted for yield potential, soil test NO_3-N and NH_4-N in the top 12 inches, and the previous crop. The recommendations assume an average of 60 lb N/acre of mineralized N which is accounted for in the table.

Table 7.2. Total N recommendations for Russet Burbank potatoes.

Soil test NO_3-N	Potential yield (cwt/acre)			
(0-12 inch)	300	400	500	600
ppm	----------------------------- (lb N/acre) -----------------------------			
0	200	240	280	320
5	180	220	260	300
10	160	200	240	280
15	140	180	220	260
20	120	160	200	240
25	100	140	180	220

Additional adjustments in the nitrogen recommendations include:

1) Applying an additional 15 lb N/acre for each ton of previous grain straw or mature corn stalk residue up to 60 lb N/acre. Mature cereal crop residues have relatively high carbon/nitrogen ratios and immobilize available N during microbial decomposition. Residues from non-cereal crops such as sugarbeets, onions, beans, peas, corn and mint have lower carbon/nitrogen ratios and decompose readily without additional N applications.
2) Subtracting 60-80 lb N/acre from the recommendation following alfalfa. Fall incorporation of alfalfa crop residue can provide a significant amount of N to the following potato crop that effectively satisfies part of the N fertilizer requirement.
3) Subtracting the N applied in the irrigation water using the formula N applied (lb N/acre) = water applied (inches) x ppm NO_3-N x 0.227
4) Making appropriate adjustments for animal manure applications
5) Fields with very sandy soils typically require an additional 30-40 lb N/acre to offset N leaching losses.

Split Nitrogen Management

The most efficient N management systems for potatoes utilize split N management with one-half to three-fourths of the total seasonal N supply side-dressed after emergence and/or applied through the irrigation system in several small applications. When properly used, split N management can significantly increase N use efficiency and reduce N leaching potential while improving potato yield and quality.

Preplant N rates used with split N management programs determined as a percentage of the total N required (Table 7.2) should be as follows:

Sands	25-30%
Sandy loams	30-40%
Silt loams	40-50%

In-Season N Applications

Following tuber initiation, in-season N applications should be made to maintain optimal N concentrations in the potato crop. In-season N can be applied by side dressing, sprinkler injection, foliar sprays or broadcast aerially as dry fertilizer. About 50-60% of the total N requirement should be applied to the crop by the time the rows close. Once tuber bulking begins, weekly crop N requirements can be estimated based on the relationship between tuber growth rates and plant N uptake based on petiole nitrate tests.

Table 7.3. Recommended petiole and soil (0-18 inches) NO_3-N concentrations for Russet Burbank potatoes during different growth stages.

Sample	Vegetative	Tuber Initiation	Tuber Bulking	Maturation
		------------------------- NO_3-N (ppm)	-------------------------	
Petiole	-----	20,000-25,000	15,000-20,000	15,000→10,000
Soil	>20	20	15-20	<15

Phosphorus Management

Potatoes commonly respond to P fertilization, particularly on soils with high pH and large amounts of free lime. Adequate soil P availability is important for early crop development and tuber initiation and also enhances tuber maturity. Phosphorus deficiencies, on the other hand, significantly reduce tuber yield and size as well as specific gravity. Phosphorus moves very slowly in soil and needs to be adequately incorporated into the soil to facilitate plant uptake. Soil test P concentrations determined by sodium bicarbonate extraction provide a good representation of the available soil P fraction in southern Idaho soils that can be related to crop yield responses. The primary factors used in determining potato P recommendations are the soil test P concentration (STPC) and the amount of free or excess lime.

Phosphorus fertilizer may be broadcast in either the fall or spring or may be banded at markout or during planting. Banding generally improves early-season P availability by concentrating the fertilizer in a narrow zone near the seed piece. Banding fertilizers containing ammonium may also increase P availability by reducing soil pH in the band. For full season P availability, it is important to raise the STPC in the root zone by to adequate levels by broadcasting P to provide the entire root system with ready access to available soil P. Liquid fertilizers such as ammonium polyphosphate (10-34-0) and dry fertilizers such as monoammonium phosphate (11-52-0) are equally effective P sources for potatoes as long as they are managed properly.

Table 7.4. Phosphorus fertilizer recommendations for Russet Burbank potatoes.

Soil Test P	Percent Free Lime			
(0-12 inch depth)	0	4	8	12
ppm	(lb P_2O_5/acre)			
0	320	360	400	440
5	240	280	320	360
10	160	200	240	280
15	80	120	160	200
20	0	40	80	120
25	0	0	0	40
30	0	0	0	0

Apply an additional 40 to 80 lb P_2O_5/acre as a starter at planting for soil test P levels below 30 ppm. Starter bands placed slightly above seed piece depth are most effective in enhancing early P uptake.
Add 25 lb P_2O_5/acre for each additional 100 cwt/acre above 400 cwt/acre.

Sprinkler application of P fertilizer is effective for correcting in-season potato P deficiencies as long as are active roots are near the soil surface. Potato root density increases near the soil surface once the canopy starts to shade the hill. This is important since P applied by sprinklers only moves about 2 inches into the soil. Petiole P concentrations usually respond within about 10-14 days after application. Consequently, the P fertilizer should be applied through the sprinkler system before P deficiencies develop.

Petiole P concentrations can provide a good indication of potato P status. Total phosphorus concentrations in the fourth petiole from the growing point should be maintained above 0.22% to provide sufficient P to satisfy both vegetative and tuber growth requirements. Petiole sampling for P should begin at or shortly after tuber initiation and continue at weekly intervals through most of the tuber bulking period.

Potassium Management

Yield and Quality

Potassium availability influences tuber yield and size as well as a number of tuber quality factors including specific gravity, blackspot bruise susceptibility, chip and fry color, and storage quality. Potassium deficiencies decrease photosynthesis, reducing dry matter and starch formation. When K uptake is excessive, surplus K is translocated to the tubers causing increased tuber water content and decreased specific gravity.

Potassium Uptake

The optimum tuber K concentration for maximum dry matter production is 1.8%. At this concentration, about 0.5 lb K_2O is required to produce 1 cwt of potatoes. A potato crop bulking at 7 cwt/acre/day requires about 3 lb K/acre/day to maintain optimum dry matter production. Potassium fertilization programs should be designed to provide sufficient K to maintain optimum plant concentrations throughout the tuber bulking period.

Preplant Potassium Fertilizer Recommendations

Table 7.5. Potassium fertilizer recommendations for Russet Burbank potatoes.

Soil Test K	Potential yield (cwt/acre)			
(0-12 inch)	300	400	500	600
ppm	----------------------------- (lb K_2O/acre) -----------------------------			
25	550	600	650	700
50	450	500	550	600
75	350	400	450	500
100	250	300	350	400
125	150	200	250	300
150	50	100	150	200
175	0	0	50	100

The probability of obtaining a positive yield response to K fertilization generally increases as the sand content of the soil increases in order: loamy sands>sandy loams>loams>silt loams. In general, K source has relatively little effect on total yield, although K_2SO_4 tends to produce slightly higher percentages of large No. 1 tubers and higher specific gravities than KCl, particularly when K fertilizer is applied at high rates shortly before planting.

Banded K fertilizer is generally not as effective as broadcast K when the bulk of the seasonal K requirement is applied at or prior to planting. If banded, K rates should be kept below 50 lb K_2O/acre to avoid crop damage due to fertilizer salt effects. Fertilizer rates exceeding 300 lb K_2O/acre should be split between fall and spring applications to avoid yield losses. Yield reductions have been obtained with spring applications of 400-600 lb K_2O/acre.

In-Season Potassium Applications

Applying all K preplant is usually more effective than applying most or all of the seasonal K supply via fertigation. Studies conducted in Idaho and Washington shows that applying over 50 % of the seasonal K requirement during tuber bulking reduces tuber yield and specific gravity compared to preplant applications. Studies also show that there is no consistent difference between the effectiveness of the K sources KCl, K_2SO_4, and KTS when applied through the irrigation system. However, in-season applications greater than 50 lb K_2O/acre should be avoided because of the increased probability of tuber quality reductions. Potassium fertilizer should not be applied later than 30 days before vine kill.

Petiole K Responses

Petiole K concentrations generally decrease with time following tuber initiation. The rate of decrease depends on soil K availability and vine and tuber growth rates. Research with Russet Burbank shows that a petiole K concentration of 7.0 to 7.5% is adequate to maintain optimal tuber growth rates and yield.

Petiole K concentrations will respond to in-season K applications when plant K levels are deficient. However, there is a 2-3 week lag period between the time that K fertilizer is injected and the time petiole K concentrations change, although sometimes petiole K doesn't increase but levels off instead of continuing downward. As a result, K applications should be made 15-20 days before the date petiole K concentrations are estimated to drop below the sufficiency level.

Sulfur

Application of sulfur (S) is usually needed in areas where soil S levels are below 15 ppm and S concentrations in the irrigation water are naturally low. Other plant available forms of S include S mineralized from soil organic matter and crop residues and S stored as gypsum ($CaSO_4$) in the crop root zone.

Sulfur is applied as a sulfate source or as elemental S. Sulfate-sulfur (SO_4-S) is readily available for plant uptake, but is susceptible to leaching. Elemental S, on the other hand, needs to be oxidized to SO_4-S before it can be taken up by the plant roots. When applying elemental S, there often is a significant time lag in the conversion to SO_4-S due to the initially low activity of S-oxidizing bacteria. This is particularly true for cold, wet soil conditions that further slow the oxidation process.

Application of S fertilizer should be considered when soil SO_4-S concentrations at the 0-12 inch depth are below 15 ppm and SO_4-S concentrations in the irrigation water are below 5 ppm. A preplant application of 30-40 lb SO_4-S/acre as ammonium sulfate, potassium sulfate, or urea-sulfuric acid should satisfy the crops S requirement. However, potatoes do respond well to applications of soluble S sources injected through the sprinkler system during tuber growth. Total S concentrations in petioles below 0.20% indicate a potential need for supplemental S applications. As with other nutrient concentrations, trends in petiole S concentrations need to be monitored on a weekly basis to provide a reliable estimate of plant S status.

Calcium and Magnesium

Although both calcium (Ca) and magnesium (Mg) are essential for plant growth, they are usually present in adequate amounts in calcareous, alkaline soils and in irrigation waters. Some deficiencies have been observed in very sandy soils or in acid soils where supplemental applications of Ca and Mg were needed to meet tuber growth requirements. Exchangeable soil Ca concentrations less than 300 ppm indicate a need for supplemental Ca which can be met with preplant applications of 200 lb Ca/acre. Magnesium deficiencies can develop at exchangeable soil Mg levels below 100 ppm. Broadcast applications of 100 lb/acre as magnesium sulfate or potassium-magnesium sulfate, or band applications of 20 lb Mg/acre should satisfy crop requirements. Calcium and magnesium can be applied as dolomitic lime when increases in soil pH are desired.

Some tuber quality disorders such as internal brown spot are associated with Ca deficiencies. To improve tuber Ca uptake, Ca fertilizer should be placed in the zone of tuber formation to facilitate uptake by the stolon roots. Fertilizers such as calcium nitrate, calcium-ammonium nitrate and calcium sulfate can be used to supply Ca without significantly increasing the soil pH.

Calcium applied to foliage is not translocated to the tubers but may help satisfy some of the Ca requirement of the leaves when deficiencies develop. Immobility of Ca in soils and plants also limits the effectiveness of sprinkler-applied Ca. Foliar sprays of magnesium sulfate can be applied to correct Mg deficiencies when petiole concentrations are less than 0.3%.

Micronutrients

Micronutrients are largely supplied to plants from soil mineral and organic sources. The elements zinc (Zn), manganese (Mn), iron (Fe), and copper (Cu) are positively charged ions that are exchanged with the surfaces of soil clay particles and are released as soil minerals weather and organic matter decomposes. Boron (B) is also contained in soil minerals and organic matter and can be present in significant amounts in irrigation water. The availability of each of these micronutrients decreases substantially as the soil pH increases from 7.0 to 8.0 and above. Critical soil micronutrient concentrations for potatoes are presented in Table 7.6.

Table 7.6. Adequate DTPA-extractable soil micronutrient concentrations for potatoes.

Zn	Mn	Fe	Cu	B
ppm				
>1.0	>6-8	>4.0	>0.2	>0.5

Zinc

Zinc fertilization may be required on calcareous soils, particularly in areas where topsoil was removed by erosion or land leveling. For soils with Zn concentrations less than 1 ppm, a broadcast application of 10 lb Zn/acre should be applied and incorporated prior to planting. Compared to broadcast rates, banded Zn rates can be reduced by up to 50 % due to higher fertilizer uptake efficiency. Zinc fertilizer sources with high percentages of water-soluble zinc, such as $ZnSO_4$, ZnDTPA, and zinc lignosulfate, should be used to maximize uptake efficiency. Zinc will move through the phloem tissue from the leaves to the tubers and foliar sprays of Zn sulfate or chelates are effective in correcting Zn deficiencies.

Manganese

On neutral to acid soils, manganese (Mn) can be broadcast and incorporated prior to planting at 5-10 lb Mn/acre to correct Mn deficiencies. On calcareous soils, Mn should be banded or applied as a foliar spray to minimize soil fixation. Applying 5 lb Mn/acre in a band near the seed piece has been effective in providing adequate Mn to potatoes when soil concentrations are low (<6-8 ppm). Manganese will also move from the leaves to the tubers when applied as a foliar spray. Manganese chelates and $MnSO_4$ are effective Mn sources for foliar applications.

Boron

Boron (B) fertilizers may be needed where soils and irrigation waters have naturally low B concentrations. Broadcast applications of 1-2 lb B/acre should be made prior to planting when soil test B concentrations are below 0.5 ppm. Band applications should be avoided due to the increased likelihood of B toxicity. Sodium borates, Solubor and boric acid can be applied as foliar sprays, but B is not translocated from the leaves to the tubers in appreciable amounts.

Iron

Most soils in Idaho do not require iron (Fe) applications for potatoes. Band applications of chelated Fe on calcareous soils may be beneficial when soil Fe concentrations are low. Iron is relatively immobile in soils and in plant tissue. Consequently, multiple applications of Fe sulfate or chelates to the foliage may be required to correct Fe deficiencies.

Copper

Copper (Cu) concentrations in mineral soils are usually sufficient for adequate plant growth. Copper has intermediate mobility in plant tissue and foliar sprays of Cu sulfate or chelates applied during tuber bulking are effective in increasing petiole Cu concentrations. Copper is a common component of certain potato fungicides that can provide significant amounts of Cu to the plant.

Chloride

There is generally enough chloride (Cl) present in irrigation water or potassium fertilizer (KCl) to provide adequate chloride for a potato crop. Deficiencies may occur with irrigation waters containing little Cl when all of the K is applied as a non-chloride source such as K_2SO_4 or KTS.