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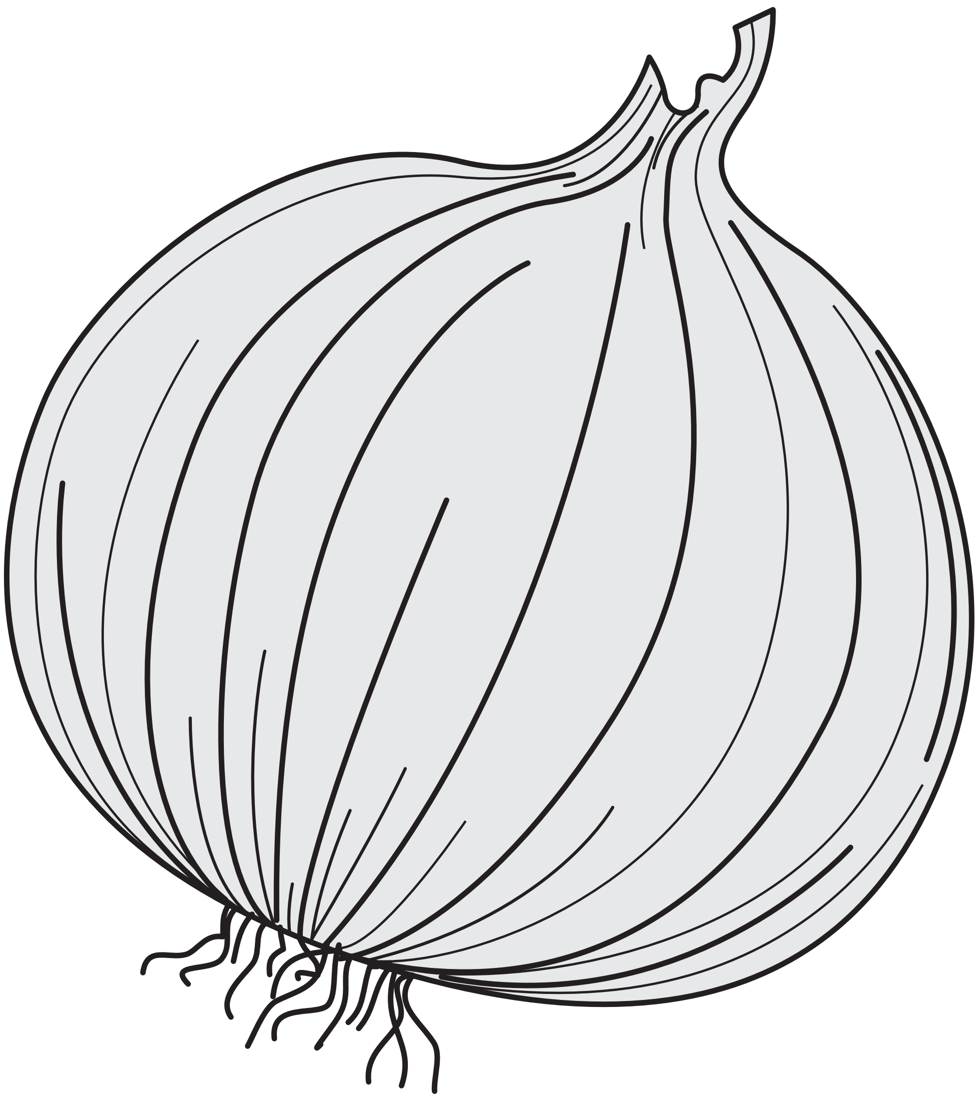
Nutrient Management for Onions in the Pacific Northwest



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What's inside?

This nutrient management guide is designed to assist onion growers and crop advisors in producing a high-quality crop while protecting the environment from excess nutrients. Nutrient management strategies recommended here are based on data accumulated over many growing seasons with many different onion varieties in Idaho, Washington, and Oregon.

This publication provides current information on:

- How onions grow and how their growth pattern affects nutrient needs
- Timing and amount of crop nutrient uptake
- Keys to managing nitrogen efficiently
- Ways to monitor crop N status during the growing season
- How to assess the need for P, K, S, and micronutrient fertilization
- Fertilizer sources and application methods
- How to assess the need for lime on sandy soils in the Columbia Basin

Key points

Crop nutrient uptake

- The amount of nutrient uptake by an onion crop is very small from germination to bulb initiation.
- The period of rapid nutrient uptake starts at bulb initiation and continues through bulb growth.
- About 80 percent of the nutrients taken up by the crop are removed in the bulbs.

Nitrogen

Use these management strategies to efficiently utilize N:

- Credit N from nonfertilizer sources in determining N fertilizer application rates.
- Apply most or all of the N fertilizer as sidedress applications or through sprinkler or drip irrigation.
- When economically feasible, use improved irrigation practices to minimize deep percolation losses.
- Use plant tissue tests to assess the need for supplemental fertilization.
- Grow deeper rooted crops after onions to recover nitrate-N leached beyond the root zone.

Phosphorus

Take the following soil and crop management factors into consideration when determining P fertilizer application methods and rates:

- Soil test value (ppm)
- Soil free lime (calcium carbonate) concentration
- Fumigation. Soil fumigation prior to seeding onions might increase P fertilizer requirements. Fumigation kills the mycorrhizal fungi that help onion roots take up P from soil.

Acid soils in the Columbia Basin

- Soil acidity (pH less than 5.5) can reduce yield. On sandy soils, soil pH can fluctuate by 1 to 2 pH units during the year, depending on fertilizer and crop management practices.
- Soil acidity can be corrected by applying and incorporating lime before planting.
- Fertilization practices can have a dramatic effect on soil pH on sandy soils.
- Do not apply N and K fertilizers preplant on sandy soils subject to soil acidity problems.
- Reduce or eliminate application of acid-forming fertilizers such as mono-ammonium phosphate (e.g., 11-52-0), urea-sulfuric acid, and ammonium sulfate.

Contents

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Nutrient Management for Onions in the Pacific Northwest

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Onions are a high-value crop. Both high yield and quality are important economic considerations. Components of bulb quality include size, appearance, percentage of single-centered bulbs, and susceptibility to sprouting and decay in storage. Nutrient supply interacts with other management, pest, and climatic factors to affect quality and yield.

This nutrient management guide is designed to assist onion growers and crop advisors in producing a high-quality crop while protecting the environment from excess nutrients. Excess nitrate-nitrogen can leach below the root zone and contaminate groundwater, while excess phosphorus can be carried into lakes and streams by surface water runoff.

Nutrient management strategies recommended here are based on data accumulated over many growing seasons with many different onion varieties in Idaho, Washington, and Oregon. The field research database supporting this onion nutrient management guide probably is more extensive than for any other vegetable crop grown in the Northwest, with the exception of potatoes.

This guide focuses primarily on onion production in the Treasure Valley and the Columbia Basin. The Treasure Valley onion production area is within a 50-mile radius of Ontario, Oregon on the Snake River plain and along the tributaries of the Snake River. The Columbia Basin production area in central Washington and north central Oregon includes approximately 750,000 acres irrigated by water from the Columbia and Snake Rivers.

Growth and development

Understanding how the onion plant grows and develops is a key part of developing a strategy to supply nutrients for optimum bulb yield and quality.

An onion bulb is different from a root (such as a sugar beet) or a stem (such as a potato). Each onion "ring" is called a bulb scale in botanical terminology and is comprised of the base of a leaf. We describe onion growth and development during the following growth phases (Table 1):

- Germination
- Leaf growth
- Bulbing, or bulb initiation
- Bulb growth
- Maturation

Table 1.—Growth stages for seeded onions in the Pacific Northwest.

Growth phase	Numerical growth stage	Approximate days after planting	Approximate calendar date (April 1 planting)	Description
Germination	1	7 to 30	Apr 20	Radicle and flag leaf emergence
Leaf growth	2	30 to 50	May 10	1 to 2 true leaves
	3	50 to 70	May 30	3 to 4 true leaves
Bulbing or Bulb initiation	4	70 to 90	June 20	5 to 7 true leaves; bulb diameter is twice that of the neck
Bulb growth	5	90 to 110	July 10	8 to 12 true leaves; bulb diameter 1 to 1.5 inches
	6	110 to 130	July 30	Bulb diameter 1.5 to 3 inches
	7	130 to 150	Aug 20	Bulb diameter greater than 3 inches
Maturation	8	150+	Aug 30	Bulb enlargement near completion; more than 50 percent tops down
	9			Field curing period

Adapted from Schwartz and Mohan (1995).

Germination

Onion seeds can germinate at low soil temperatures. Soil temperatures above 34 to 37°F stimulate seed germination. Seed germination is most rapid and uniform at soil temperatures above 52°F.

Leaf growth

Onions have an unusually long period of slow growth to the 3-leaf stage. Their early vegetative growth rate is about half that of other cool-season crops such as lettuce and beets. The period of slow growth lasts about 50 to 70 days after planting under typical weather conditions. Onions planted in late March or early April typically reach the 3-leaf growth stage by late May or early June. During this early leaf growth phase, nutrient needs are very low.

Other cultural factors such as herbicide damage or soil acidity can further reduce early vegetative growth. Slow early growth caused by weather conditions sometimes is incorrectly attributed to nutrient deficiencies.

Rapid leaf growth begins when the onion plant has three leaves. Each emerging leaf is larger than the previous leaf. Leaf growth rate increases with temperature. Leaf growth requires an air temperature of at least 40°F and reaches a maximum at about 80°F.

Onion root growth occurs at a regular pace during leaf growth. New roots are produced from the bulb basal plate as leaves develop above ground. The shallow, sparsely branched root system of the onion plant has important implications for nutrient management. See "Root growth and development" (at left) for more details.

Root growth and development

Onions have a shallow, sparsely branched root system with most roots in the top foot of soil. Rooting density decreases with soil depth. The sparse, shallow rooting of onions has important implications for management of relatively immobile nutrients (P, K, and some micronutrients such as Zn). The unbranched root system of onions is less effective than most crop plants in extracting immobile nutrients. Therefore, onions are more susceptible than most crops to deficiencies of these nutrients.

The shallow root system of onions also is an important consideration for efficient management of mobile nutrients such as nitrate-N and sulfate-S. Mobile nutrients can be lost from the root zone by over-irrigation. With furrow irrigation, mobile nutrients move to bed centers, where they typically become available later in the season when onion roots proliferate across the beds.

Onions are highly dependent on arbuscular mycorrhizal fungi for uptake of phosphorus from soils with low to medium soil test P concentrations. Mycorrhizal fungi produce a network of threadlike hyphae that extend from the onion roots into the soil, greatly increasing the absorptive surface area of the roots. Mycorrhizal fungi also can increase the uptake of zinc and other micronutrients in some high-pH calcareous soils.

Mycorrhizal fungi usually are abundant in agricultural soils, except when nonhost crops are grown, soil is fumigated, or high soil test P is present. Crops that do not host mycorrhizal fungi include sugar beets and mustards (e.g., canola).

Nematode feeding and root diseases can cause weak, poorly developed root systems.

Bulbing

The bulbing growth stage is considered to begin when bulb diameter reaches twice that of the neck. Most onion varieties initiate bulbs after six to eight leaves have been produced. Bulbing begins in response to increasing day length. Major onion types differ in the minimum day length needed to initiate bulbing. The minimum day length needed for bulbing is much shorter for early, overwintering onions, such as Walla Walla, than for spring-seeded onion varieties.

Temperature and light spectral quality also affect the onset of bulbing, but these effects are minor compared to day length. Once day length initiates bulbing, the higher the temperature, the earlier bulbing will occur. Densely planted onions have more shaded leaves and begin bulbing earlier because of altered light spectral quality. Shading initiates bulbing by providing more far red light and less red light to onion leaves.

Leaves continue to emerge during bulbing and bulb growth. Most onion varieties grown in the Pacific Northwest produce 12 to 14 true leaves.

Bulb growth

The onion plant has the highest demand for water and nutrients during bulb growth. Onion dry matter accumulation rates during bulb growth are comparable to those of a rapidly growing forage crop. Dry matter accumulates at a rate of 100 to 200 lb per acre per day (1,000 to 2,000 lb fresh weight per acre per day) during the peak growth period (Figure 1a).

Maturation

The timing of onion harvest depends on market opportunities, weather, and the planned storage period. As bulb growth slows, the onion neck becomes soft and the plant falls over. Maturation commonly is evaluated by the percentage of tops down and by the amount of dry leaves present.

Achieving a proper degree of maturation before harvest is a key factor in producing high-quality onions for storage. Growers sometimes suspect high levels of nutrients, particularly nitrogen, as the cause of poor maturation in the field and decay in storage. Usually, however, these problems result from a combination of environmental and crop management factors.

Environmental factors that can delay maturation and increase storage loss include hail damage to plants, a cooler than normal growing season, or wet weather for field curing of bulbs. Management factors such as sparse, uneven plant populations, a late planting date, water stress, or nutrient deficiencies also can slow development and maturation.

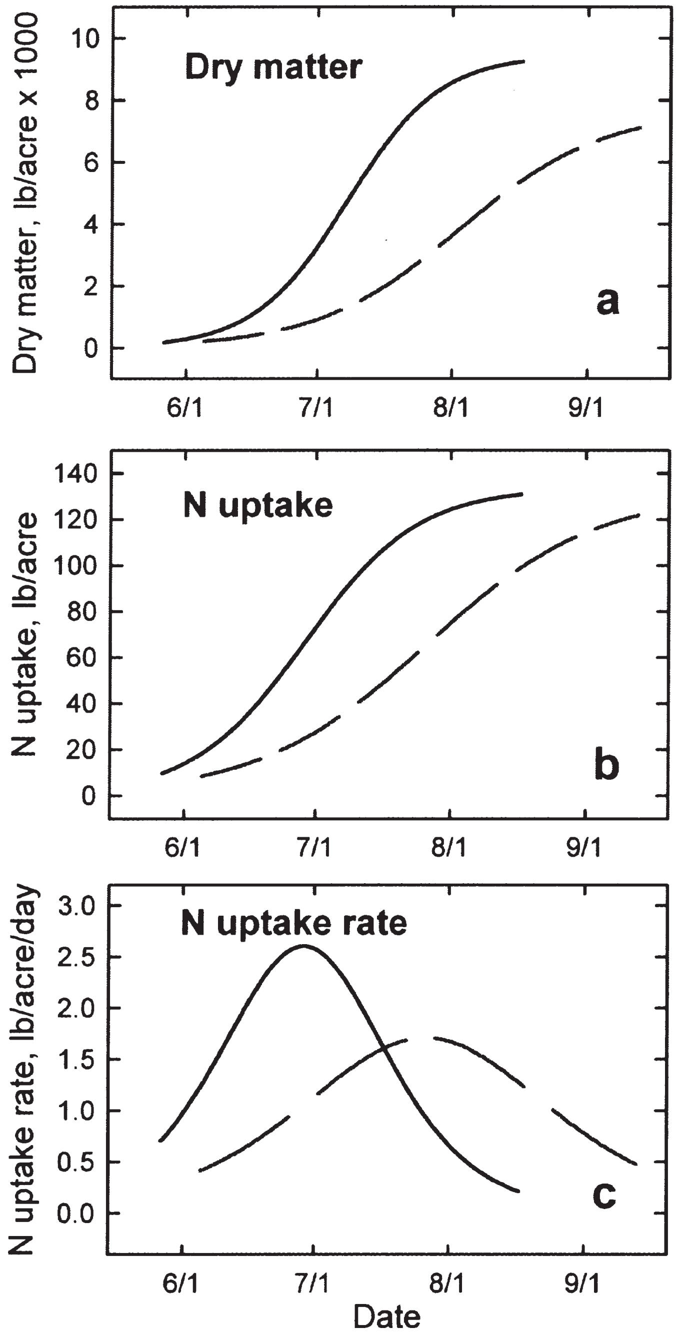


Figure 1.*—Onion (bulb + leaves) dry matter (a), nitrogen uptake (b), and N uptake rate (c) for yellow onions at a field location in the Columbia Basin near Connell, WA (solid line) and at five field locations in the Treasure Valley near Parma, ID (dashed line). Columbia Basin data is for the 1998 season; it is averaged across two varieties, 'Prince' and 'Vision.' Average bulb yield (fresh wt. basis) for the two varieties was 840 cwt per acre (42 tons per acre) at the Columbia Basin site and 630 cwt per acre (32 tons per acre) at the Treasure Valley sites. Sources: Don Horneck, Oregon State University Extension Service, Umatilla County; Gary Pelter, Washington State University Cooperative Extension; Brad Brown, University of Idaho Parma Research and Extension Center.*

Market classes for harvested onions

Premium prices are paid for large onions. After harvest, onions are sorted and marketed in the following size classes:

- Super colossal (Onion count must be 28 to 36 per 50-lb bag; diameter greater than 4¼ in)
- Colossal (> 4 in)
- Jumbo (3 to 4 in)
- Medium (2¼ to 3 in)

Markets for small onions (1 to 2¼ in) are limited.

Nitrogen

Crop N uptake

Nitrogen concentrations in bulbs of red, yellow, and white onion varieties are similar. Crop N removal (tops + bulbs) averaged about 140 lb N per acre in Columbia Basin trials (Figures 2 and 3). Crop N uptake typically ranges from 0.14 to 0.24 lb N per cwt fresh bulb yield. At harvest, about 15 to 40 lb N is present in tops, with the remainder present in bulbs (Figure 2). Crop N uptake rates during bulb growth range from 1 to 3 lb per acre per day (Figure 1c, page 5).

Strategy for N management

These management strategies help increase the efficiency of N utilization:

- Credit N from nonfertilizer sources (N in preplant soil test and irrigation water and N mineralized during the growing season) when determining N fertilizer application rates.
- Minimize preplant N fertilizer application.
- Apply most or all of the N fertilizer as side-dress applications or through sprinkler or drip irrigation.
- When economically feasible, use improved irrigation practices to minimize deep percolation losses.
- Use plant tissue tests to assess the need for supplemental fertilization.
- Grow deeper rooted crops after onions to recover N leached beyond the 2-foot depth.

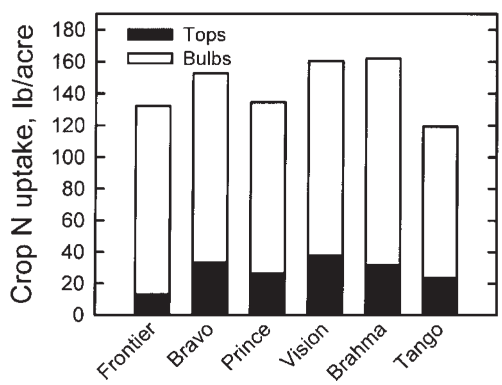


***Figure 2.**—Nitrogen uptake for six onion varieties grown at a field location in the Columbia Basin near Connell, WA. Variety descriptions: 'Frontier' is an early Japanese globe, 'Bravo' is a late U.S. Sweet Spanish, 'Prince' is a mid-late Dutch globe, 'Brahma' is a mid-late U.S. globe, and 'Tango' is a mid-late red globe onion variety. Fresh weight bulb yields ranged from 700 to 1,100 cwt per acre, with bulb dry matter of 10 to 12 percent. Sources: Don Horneck, Oregon State University Extension Service, Umatilla County; Gary Pelter, Washington State University Cooperative Extension. 1997 growing season.*

Crop N uptake vs. available N supply

Nitrogen supplied to an onion crop comes from several sources. The available N supply is made up of:

- Preplant soil nitrate N and ammonium N
- N mineralized from crop residues and soil organic matter
- N supplied in irrigation water
- Fertilizer N

Fertilizer N should provide only a portion of the available N needed to grow the crop. We recommend a regular program of soil and irrigation water testing to determine how much available N is supplied by the soil and irrigation water. In some environments, high yields can be grown with small fertilizer N inputs because of the supply of available N in soil and irrigation water.

Estimates of crop N uptake can be used to estimate the available N supply needed for crop production. With good irrigation management, an onion crop can recover 40 to 60 percent of the available nitrogen from all sources.

The 700 to 1,100 cwt-per-acre bulb yields shown in Figure 2 were produced with an available N supply (including nitrate + ammonium-N in the soil before seeding, estimated soil N mineralization, and N added in irrigation water and fertilizer) of approximately 250 to 300 lb N per acre.

Crediting available N from nonfertilizer sources

Site-specific N management requires soil and water testing to estimate the amount of N from nonfertilizer sources.

Preplant soil nitrate-N

Preplant soil nitrate-N testing is a reliable tool for adjusting N fertilizer rates to site-specific needs. Spring sampling is more accurate than fall sampling because it accounts for nitrate

Crop nutrient uptake

One of the goals of nutrient management is to supply nutrients in a timely manner to maximize crop yield and quality. Crop nutrient uptake is calculated from measurements of crop biomass (dry matter) multiplied by crop nutrient concentration. You can use this number to estimate the total supply of available nutrient needed to grow the crop under good management.

Cumulative nutrient uptake by an onion crop follows a sigmoid or s-shaped curve during the growing season. The period of rapid nutrient uptake starts during bulbing (growth stage 4 in Table 1, page 3). Onions take up more than 100 lb per acre of nitrogen, potassium, and calcium, with substantially lower amounts of sulfur, phosphorus, and magnesium (Figure 3). About 80 percent of the nutrients present in the plant at harvest are present in the bulb; the remainder is present in tops.

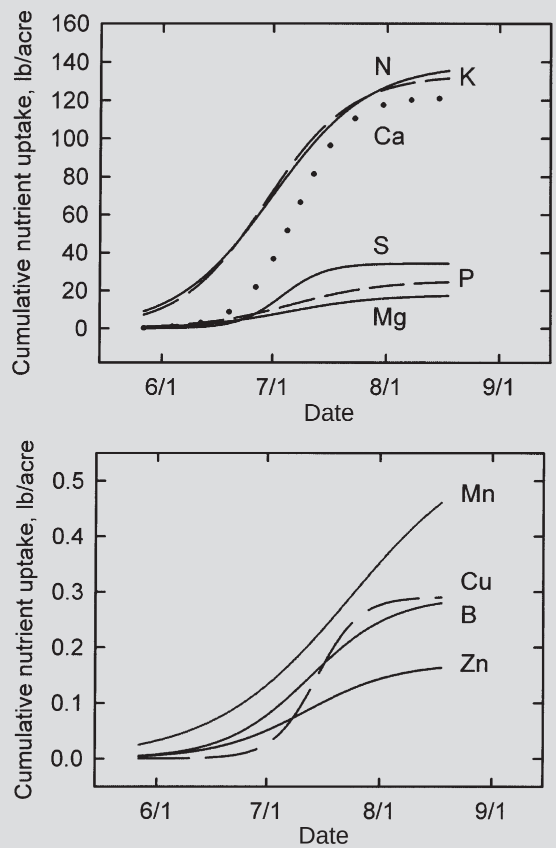


Figure 3.*—Cumulative nutrient uptake by onions (bulb + leaves) for yellow onions grown near Connell, WA. Onion tissue was harvested at 13 dates during the growing season. Data is averaged across two varieties, 'Prince' and 'Vision.' Bulb yield (fresh wt. basis) was 840 cwt per acre (42 tons per acre) under furrow irrigation. Onions were seeded March 29 and harvested September 10. The final sample was collected about 7 days before undercutting. Sources: Don Horneck, Oregon State University Extension Service, Umatilla County; Gary Pelter, Washington State University Cooperative Extension. 1998 growing season.*

Crop N uptake vs. N supplied by nonfertilizer sources

An example of how an onion crop can use nonfertilizer sources of N is shown in Table 2. In the example, available nitrogen supply was estimated for nonfertilizer sources; no fertilizer N was applied. Crop nitrogen uptake efficiency, calculated as a percentage of the available N supply, was 59 percent. This means that for each unit of available N supplied, crop N uptake increased by 0.59 units of N.

Table 2.—Example: Crop N uptake by high-yielding onions vs. available N supply from nonfertilizer sources.[a] Estimated crop N uptake efficiency = 59 percent.

Crop N uptake or available N supply	Line	Component of N budget	Nitrogen (lb/acre)
Crop N uptake	1	Tops plus bulbs[b]	160
Available N supply	2	Preplant soil nitrate + ammonium N (0 to 24 in)	76
	3	Irrigation water N (supplied via drip irrigation)	79
	4	Estimated soil N mineralization (mineralizable N soil test; 0 to 24 in)[c]	116
	5	Fertilizer N	0
	6	Total estimated available N supply (line 2 + line 3 + line 4 + line 5)	271
Crop N uptake efficiency	7	Estimated crop N uptake efficiency (line 1 ÷ line 6) x 100	59% of available N supply

[a]Yellow onions (cv. 'Vision') produced under drip irrigation at Oregon State University Malheur Experiment Station during 1995 growing season. Total bulb yield was 884 cwt per acre, with 71 percent of total yield in jumbo + colossal market grades (> 3 in diameter). In this trial, addition of N fertilizer (data not shown) did not increase bulb yield (as evaluated out of storage in December) or N uptake.

[b]Crop N uptake (tops + bulbs) determined from harvest of bulbs on September 2 prior to crop maturation.

[c]Mineralizable soil N estimated via anaerobic incubation for 7 days at 104°F (40°C).

Source: Feibert, E.B., C.C. Shock, and L.D. Saunders. 1997. Nitrogen management of precision irrigated onions. pp. 60–67. In: Proc. Western Nutrient Management Conference. Salt Lake City, UT.

movement over the winter and changes in nitrate-N that accompany decomposition of crop residues.

Collect samples from onion beds in the spring before the first irrigation. Sampling before the first irrigation is recommended because nitrate movement with irrigation water leads to more variable test results. Sample at two depths: 0 to 12 and 12 to 24 inches. Onion root systems typically reach below 12 inches during bulb growth.

The preplant soil nitrate test is strongly correlated with crop yield response to N fertilizer in the Treasure Valley (see below).

Using the preplant nitrate soil test in the Treasure Valley

Interpretation of the preplant nitrate-N test for onions in the Treasure Valley is based on extensive research. Eighteen field trials were conducted in grower fields from 1991 to 1996. Data from nine on-station trials at Parma (1978 to 1985) is also included in the database.

The objective of the research was to relate preplant soil nitrate-N values to crop yield response. Preplant soil nitrate in onion beds was measured prior to the first irrigation. N fertilizer rates ranging from 0 to 320 lb N per acre were side-dressed at bulb initiation in June or applied preplant. Growers used normal cultural and irrigation practices.

Onions were harvested and graded into market classes. The yield of large onions (jumbo plus colossal; onions > 3 in diameter) was compared among N rates at a field location. “Relative jumbo yield” was calculated for each N rate within a location as:

Relative jumbo yield (%) = A ÷ B x 100, where:

A = onion yield (> 3 in diameter) for a given N fertilizer rate

B = maximum onion yield (> 3 in diameter) for the field site in the year of the test

Relative jumbo yield did not increase in response to applied N fertilizer when preplant soil test N was above 80 lb N per acre for the 0- to 12-in depth or above 100 lb per acre for the 0- to 24-in depth (Figure 4a). Maximum onion yields occurred at much lower preplant soil test levels at many sites, particularly when large amounts of N were mineralized from crop residues and soil organic matter.

Onions required a total of 40 to 160 lb N per acre (preplant soil nitrate-N [0- to 24-in depth] plus side-dress fertilizer N) for maximum jumbo yields (Figure 4b). Onions did not require more than 160 lb N per acre for maximum yield at any site. Onion yield and size were reduced at some locations with more than 160 lb N per acre (preplant nitrate-N plus fertilizer N).

Preplant analyses for soil ammonium-N did not improve prediction of fertilizer N needs.

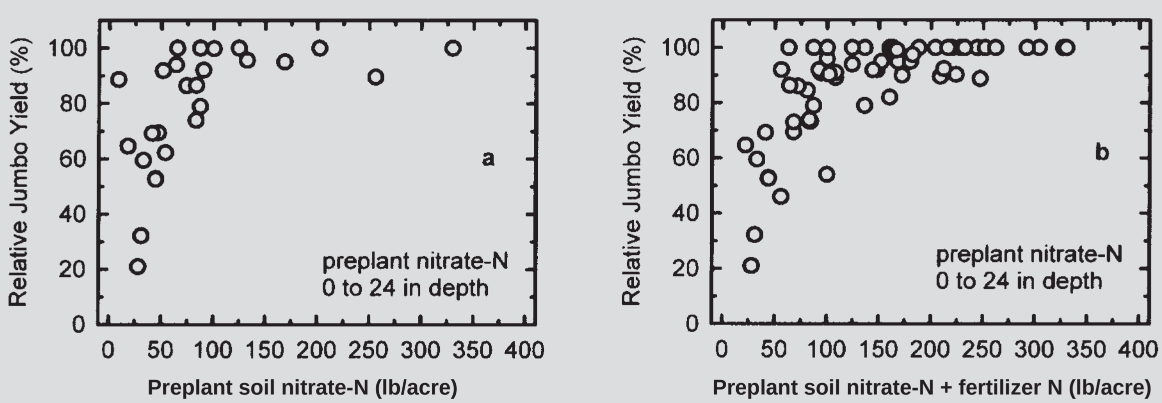


Figure 4.*—Nitrogen supply from preplant soil nitrate-N (a) and preplant N + fertilizer N (b) vs. relative jumbo yield for Treasure Valley field locations near Parma, ID. A relative jumbo yield of 90 percent or above indicates that yields at that N rate were equal to maximum yield. Source: Brad Brown, University of Idaho Parma Research and Extension Center.*

Estimating available N from mineralization

Mineralization process

Onions cannot utilize the organic nitrogen present in soil organic matter and crop residues until microbial activity releases available nitrogen (ammonium and nitrate forms). Onions take up both the ammonium and nitrate forms of nitrogen.

Crop residues decompose much more rapidly than soil organic matter. Crop residues decompose within weeks under favorable soil temperature and moisture conditions, while only a fraction (2 to 5 percent) of stable soil organic matter decomposes during a growing season. Most of the N mineralized accumulates as nitrate if it is not leached or taken up by the crop.

Estimating N mineralization

Estimates or credits for N mineralization that are used in estimating fertilizer N needs (line 8 in Table 3) include N mineralized from both soil organic matter and crop residues. N mineralization supplies a considerable amount of plant-available nitrogen during the key period for onion bulb growth (Figure 5).

The kind of crop residue affects the amount and timing of N mineralization. For example, sweet corn residue decomposes more rapidly and contains more N per acre than wheat residue (Figure 5). In Treasure Valley soils, the amount of N mineralized typically is lower with wheat as the previous crop (0 to 100 lb N/acre) than with a crop such as sweet corn (130 to 220 lb N/acre). Decomposition of wheat residue slows the rate of N mineralization early in the growing season. This effect is completed by about July 1 in the Treasure Valley. Soil N mineralization releases available N during the peak period for onion N uptake in July and August following either wheat or sweet corn.

Mineralizable N test

The mineralizable N test provides a rough prediction of N mineralization during the growing season. Mineralizable N is determined by anaerobic incubation of soil in water at 104°F (40°C) for 7 days. The high temperature used in the mineralizable N test speeds up the mineralization process and provides an estimate of season-long N mineralization in the field.

We recommend this test for trial use in the Treasure Valley. For Treasure Valley soils, there is a correlation between mineralizable N in the 0- to 12-inch and that in the 0- to 24-inch depth. Mineralizable N for the 0- to 24-inch depth is about 1.3 times the amount present in the 0- to 12-inch depth.

Collect soil samples for the mineralizable N test using the same procedure as for preplant nitrate-N. (Use the same samples for both tests.)

The mineralizable N test currently is not widely available at commercial laboratories. Check with your lab to see whether they can do this test.

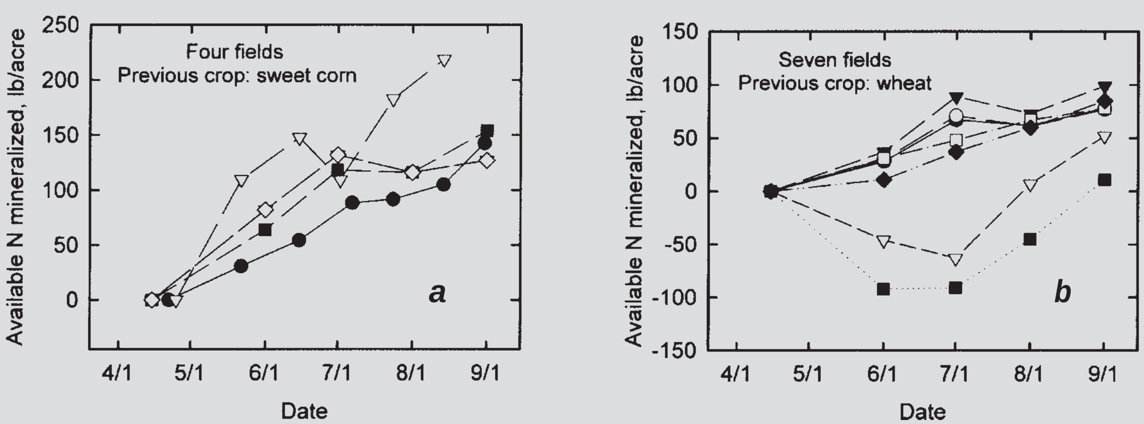


Figure 5.—*Effect of sweet corn (a) or wheat (b) previous crop on N supplied by mineralization in Treasure Valley soils. Available N was determined by the buried bag method. Sources: Brad Brown, University of Idaho Parma Research and Extension Center, and Oregon State University Malheur Experiment Station (Steiber, et al. 1995).*

Preplant soil ammonium-N

Growers sometimes include preplant ammonium-N as a credit when calculating N fertilizer requirements. Testing for ammonium-N in soil is important when N fertilizer has been applied recently, especially if the soil has been dry or cold since the application. Decomposition of crop residues that are high in N (e.g., alfalfa residue or sugar beet tops) in dry soil over the winter sometimes also results in high concentrations of ammonium-N the following spring.

Nitrogen mineralized from crop residues and soil organic matter

Soil microorganisms decompose crop residues and soil organic matter to produce the mineral forms of N (ammonium and nitrate) utilized by plants. This is an important source of plant-available N. The residue from the previous crop is an important factor determining the quantity of N mineralized. Soil temperature, moisture, and tillage also affect the rate of mineralization.

Current fertilizer guides take into account average soil N mineralization based on the previous crop, but do not require measurement of site-specific soil N mineralization potential. Recent research has focused on improving N mineralization estimates (see "Estimating available N from mineralization" at left). Research in the Treasure Valley has shown that N mineralization cannot be estimated accurately based on soil organic matter concentration.

Nitrogen supplied in irrigation water

You can determine the amount of nitrogen supplied by irrigation water by testing the water. "Effects of irrigation on N and S management" (at right) describes how to calculate an N credit for irrigation water. The efficiency of N supplied from irrigation water is similar to that of side-dress fertilizer N.

The timing of irrigation water N application coincides with crop N demand. Water is applied most frequently in July and August when onions are most active in extracting available N from the soil.

Effects of irrigation on N and S management

Plants take up most nitrogen and sulfur from the soil in the nitrate and sulfate forms. Nitrogen supplied as urea, ammonium-based fertilizers, or N mineralized from crop residues or soil organic matter is converted by microbial action to nitrate. Similarly, sulfur supplied as thiosulfate or S mineralized from soil organic matter or crop residues is converted to sulfate.

Irrigation water management is the most important tool in good management of nitrate-N and sulfate-S. These mobile nutrients move with water and are moved out of the root zone with excessive irrigation.

Irrigation water also can be a source of mobile nutrients. Water from wells or recycled irrigation water can supply significant amounts of nitrate-N or sulfate-S. Nitrate and sulfate can be present in the groundwater or might accumulate in irrigation reuse water. You can determine the amount of nitrate and sulfate in irrigation water by testing.

Only about half of the applied irrigation water is retained with furrow irrigation. Thus, you must estimate water retention when calculating the quantity of N and S applied with furrow irrigation. Calculate the amount of N or S supplied with irrigation as:

Nutrient applied (lb/acre) = A x B x C x 0.227

where:

A = irrigation water applied (inches per acre)

B = nitrate-N or sulfate-S concentration in water (mg/L)

C = decimal fraction of applied water retained in the field (for sprinkler or drip irrigation, C=1; for typical furrow irrigation systems, C = 0.5)

0.227 = conversion factor. The conversion factor is 0.227 for converting mg N/L or mg S/L to lb/acre.

Note: Units of mg per L are equivalent to ppm for water samples.

Example calculation

Your irrigation water contains 10 mg nitrate-N per L and 5 mg SO_4-S per L and you applied 48 inches of water via furrow irrigation during the growing season. Half of the applied water was retained on the field.

Nitrate-N applied = 48 x 10 x 0.5 x 0.227 = 54 lb/acre

Sulfate-S applied = 48 x 5 x 0.5 x 0.227 = 27 lb/acre

Table 3.—Worksheet for estimating fertilizer N application rate for onions.

Line	Estimate	Units	Data Source	How to Calculate	Example
1	Bulb yield	cwt per acre (fresh weight)	Production records	Choose a realistic yield goal based on production records	800
2	Unit crop N uptake	lb N per cwt of fresh bulb yield	University research	Average value is 0.19 lb N per cwt.[a]	0.19
3	Crop N uptake	lb N per acre	Calculation	Line 1 x Line 2	152
4	Crop N uptake efficiency	Percent of available N supply	University research	40 to 60%	50
5	Available N supply needed from all sources	lb N per acre	Calculation	Line 3 ÷ (Line 4 ÷ 100)	304
6	Available N supply from nonfertilizer sources	lb N per acre	Preplant soil test	Nitrate + ammonium N (0 to 24 inches)	60
7			Irrigation water test	Nitrate-N (use calculation from "Effects of irrigation on N and S management," page 11)	10
8			University research	Estimated soil N mineralization (use local values; consult your agronomist)	60
9			Calculation	Total available N supply from nonfertilizer sources (line 6 + line 7 + line 8)	130
10	Fertilizer N to apply[b]	lb N per acre	Calculation	Line 5 minus Line 9	174

[a]The usual range for bulb N uptake (fresh weight basis) is 0.14 to 0.24 lb N per cwt. The average value given here (0.19 lb N per cwt) is based on field trials with bulb yields of 400 to 1,030 cwt per acre.

[b] See "In-season fertilizer N application," page 13, for most efficient fertilizer N application methods.

Estimating the N fertilizer application rate

After estimating credits from nonfertilizer N sources, you can roughly estimate the amount of N fertilizer needed (Table 3). The lines in the worksheet with the greatest amount of uncertainty are crop N uptake efficiency (line 4) and estimated soil N mineralization (line 8). Most university fertilizer guides take into account average N uptake efficiency and soil N mineralization, but do not explicitly list these values. We show these factors in our worksheet to demonstrate how important they can be in accurately estimating N fertilizer rates. Consult your agronomist to determine local values for crop N uptake efficiency and soil N mineralization.

Use the worksheet only to roughly assess overall fertilizer N needs. The timing and method of N fertilization is more critical than the total amount of N fertilizer applied.

The worksheet can underestimate fertilizer N needs if soil mineralization is less than expected or the timing of soil N mineralization does not coincide with crop needs. If the worksheet calculates a zero N fertilizer rate, monitor root nitrate-N status to assure adequate N availability. (See “Monitoring crop N status during the growing season,” page 14.)

If you apply organic fertilizer sources (e.g., compost) to supply available N, you will need to estimate the fraction of applied N that is available to the onion crop. *Fertilizing with Manure*, PNW publication 533, provides general estimates of first-year compost or manure N availability.

In-season N fertilizer application

Nitrogen fertilizer is utilized most efficiently when it is applied just prior to, or during, the period of rapid crop N uptake (Figure 1, page 5). The period of rapid crop N uptake begins at bulb initiation (growth stage 4; Table 1, page 3).

Application methods

Side-dressing

Side-dressing, the knifing of N into the shoulder of the onion beds, is one of the most efficient application methods for furrow-irrigated onions, especially when delayed until bulb initiation. Side-dress N can be applied only as long as fertilizer application equipment can get into the field without damaging onion plants.

Where leaching losses are high, split applications usually are more effective than a single side-dress application. Regardless of the number of applications, the amount of N applied at one time should not exceed 100 lb N per acre. Typical side-dress N application rates are 40 to 80 lb N per acre per application.

At high side-dress N rates (> 160 lb N per acre), onion yields sometimes were reduced in Treasure Valley trials. The yield reduction at high N rates probably was caused by root injury via ammonia toxicity or high soluble salt concentrations.

Sprinkler or drip irrigation

You can meet crop N needs efficiently by applying N fertilizer with sprinkler or drip irrigation. Consider crop N uptake rates (Figure 1c, page 5) in choosing the timing and amount of drip or sprinkler-applied N. Maximum crop N uptake rates for onions are 2 to 3 lb N per acre per day.

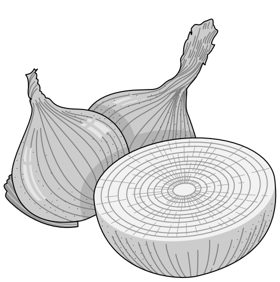
Furrow irrigation

Adding N to water used for furrow irrigation is a less precise method and generally is not recommended. Problems with water-run N applications include:

- Furrow irrigation does not distribute water evenly across the field. More N is applied to the top of the field than to the lower end of the field.
- Water leaving the field contains some of the fertilizer N.
- Adjacent furrows in the same field might be irrigated over a period of days (e.g., irrigation of every fifth furrow), making it difficult to synchronize water application and fertilizer application.

We recommend choosing another method of N application to replace water-run N applications. If water-run application is necessary, the following precautions can reduce or eliminate N loss from the field:

- Begin N application when water has advanced 30 percent of the way through the field. This practice avoids excessive application of N to the top part of the field.
- Shut off the fertilizer injection unit before water reaches the end of the field. This practice avoids N fertilizer loss in irrigation water runoff.
- Collect and reuse irrigation water.



Fertilizer N sources

The timing and method of fertilizer N application is more important than the N source. (See "In-season N fertilizer application," page 13.) In-season application of ammonium nitrate, ammonium sulfate, calcium nitrate, and urea-ammonium nitrate produced similar onion yield and quality in a 2-year Treasure Valley trial. N fertilizers differ in their effects on soil pH. (See "Acid soils in the Columbia Basin" at right.)

Controlled-release N fertilizer products offer promise for efficient utilization of N, particularly in soils prone to leaching. Polymer-coated urea (PCU) fertilizers are being evaluated for onion production in the Pacific Northwest and other western states. The polymer coating slows the release of available N. Coating urea with sulfur also reduces the rate of available N release from fertilizer granules. Sulfur-coated urea increased fertilizer N efficiency compared to uncoated urea in some Treasure Valley trials.

Monitoring crop N status during the growing season

There are two ways to monitor the success of nitrogen management practices during the growing season: soil testing and plant tissue testing. These tools can assist you in managing N to meet goals for crop yield, quality, and environmental protection. You can use them to determine the need for in-season N application when other data (see "Estimating the N fertilizer application rate," page 13) indicates that little or no fertilizer N is needed. They also can help you diagnose the cause of poor crop growth.

Both monitoring methods have limitations. Both are a "picture in time," reflecting current soil and plant N status. To get reliable information from these tools, collect samples periodically during the season.

Acid soils in the Columbia Basin

Soil acidity (pH less than 5.5) has been identified as a contributing factor in stand reduction and poor crop performance on loamy sand or sandy loam Columbia Basin soils. These soils were naturally neutral or slightly alkaline before cultivation; they have been acidified by N fertilization and other cropping practices.

Diagnosis

Soils with identified soil acidity problems are poorly buffered, with cation exchange capacities (CEC) of 5 to 10 meq/100 g. On these sandy soils, pH can fluctuate by 1 to 2 units during the year, depending on fertilizer and crop management practices. Soil pH usually is highest in winter or early spring. Fertilizer salts and soil biological activity reduce pH (increase soil acidity) during the growing season. Thus, preplant soil pH measurements might not reflect soil pH values during the growing season.

Soil acidity problems can occur even in fields that contain areas of calcareous (pH 8) soil. Therefore, pH might need to be adjusted on a site-specific basis within the field.

Soil acidity problems in Columbia Basin fields often look like a seeding or tillage problem. Often, plants in entire rows are missing, while plant stands in nearby rows are acceptable. This phenomenon likely is due to differences in depth of tillage. Deeper tillage often brings higher pH soil to the surface.

Plants affected by soil acidity exhibit slow, stunted growth. Root systems are poorly developed and might have some stubby roots similar to those injured by nematode feeding. Manganese in leaf tissue often is above 150 ppm, and soil pH in the onion row is below 5.

Soil and plant tissue tests for soil acidity

To anticipate and evaluate potential soil acidity problems, use the following soil tests:

- Lime requirement (one-quarter strength SMP buffer). This test measures reserve acidity present on cation exchange sites. It is used to evaluate the potential for pH decline during the growing season and the amount of lime needed to correct soil acidity. The standard lime requirement test (full-strength SMP buffer) cannot accurately determine lime requirements on very sandy soils.
- Exchangeable calcium. Exchangeable Ca below 3 meq/100 g indicates the potential for soil acidity problems.
- Soil pH. This test measures acidity in soil solution. Collect soil from the rooting depth (0 to 6 inches) in the onion row to monitor pH during the growing season.

High manganese (Mn) concentrations in onion leaf tissue can be an indicator of potential soil acidity problems. Further soil testing should be done when leaf Mn is greater than 100 ppm. Leaf tissue Mn concentrations can be misleading if foliar Mn has been applied.

Suggested management practices

Soil acidity can be corrected by applying and incorporating lime before planting. Correcting a soil acidity problem during the season is difficult because liming materials have low water solubility and remain near the soil surface.

Preplant application of 500 to 1,000 lb agricultural lime usually is sufficient to correct soil acidity problems for an onion crop on very sandy Columbia Basin soils. Use shallow tillage to incorporate lime into the top 6 inches of soil.

Fertilization practices can have a dramatic effect on soil pH. If possible, avoid preplant application of N and K fertilizers on sandy soils subject to soil acidity problems. The salt provided by these materials can reduce pH by 1 unit (e.g., from 6 to 5). Chloride from fertilizer sources such as potassium chloride also can increase plant injury by increasing uptake of Mn. Apply N and K in smaller increments during the growing season. Reduce or eliminate application of acid-forming fertilizers such as mono-ammonium phosphate (e.g.,11-52-0), urea-sulfuric acid, and ammonium sulfate.

Soil nitrate monitoring

You can monitor soil nitrate to assess available N in the root zone. It is most valuable early in the growing season when onion root systems are small and root samples are difficult to collect for nitrate analysis. Under furrow irrigation, nitrate concentrations are uneven across the bed, resulting in highly variable test results.

Sampling

To monitor early-season N availability, collect samples to a 6-inch depth within the row. If ammonium-based fertilizers or urea were applied recently, include ammonium-N analyses.

Early-season interpretation

Because of the variability typically observed in soil nitrate testing, we address only in-row nitrate concentrations in the high (above 20 ppm) and low (below 5 ppm) range. High nitrate-N concentrations (above 20 ppm in the root zone) indicate that N currently is not limiting crop growth, and N fertilizer applications should be delayed. Low nitrate concentrations (less than 5 ppm in the root zone) suggest that N might be limiting growth.

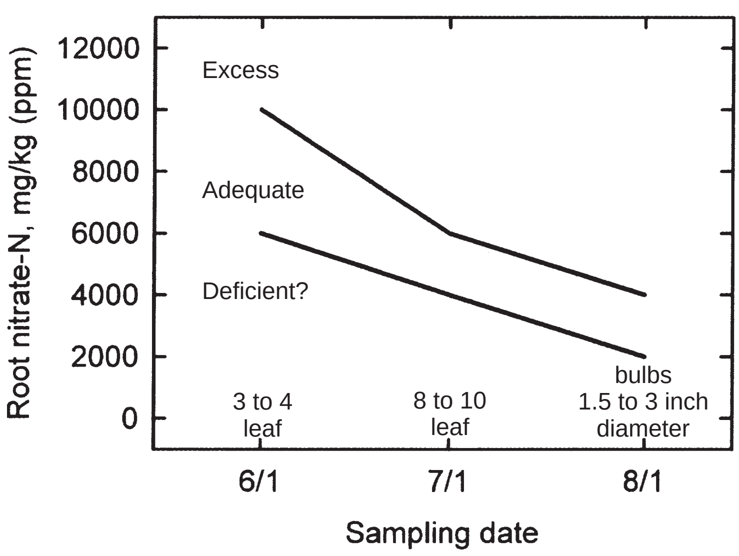


__Figure 6.__—Interpretation of onion root nitrate-N test. The adequate range includes root nitrate-N concentrations (dry wt. basis) associated with maximum bulb yield in Treasure Valley field trials. This interpretation is based on N fertilizer trials where side-dress N was applied during bulb initiation (5- to 7-leaf stage) with typical furrow irrigation water management. Maximum onion yield and size can be produced with lower root nitrate concentrations when low concentrations of nitrate are provided consistently by irrigation water, N mineralized from crop residues or soil organic matter, or slow-release N fertilizers. Source: Brad Brown, University of Idaho Parma Research and Extension Center.

Root nitrate monitoring

Onion roots display the greatest response to available N supply of any plant part. Root nitrate-N concentrations vary from more than 10,000 ppm (dry weight basis) after side-dress N fertilizer applications to less than 1,000 ppm for onions that are nitrogen deficient.

You can use leaf N as an indicator of plant N status at the 3- to 5-leaf stage, when root systems are small and root samples are difficult to collect. Leaf tissue concentrations above 3.5 to 4 percent N (dry wt. basis) in the most recently matured leaf are sufficient.

Root sampling

Collect root samples from 20 to 30 representative plants. Remove the plant from the field using a small spade or other lifting tool, being careful not to cut off or lose roots. Wash with water to remove soil and then cut off the roots at the base of the plant. After cutting off the onion roots, pack the washed roots loosely in a paper bag. For overnight shipment to the laboratory, pack the roots so that they start to dry in transit and do not become a slimy mess. Roots should reach the laboratory within 24 hours of sampling.

Interpretation

Root nitrate-N analyses are an indicator of plant N status at a particular time. This test does not reflect nitrate that might become available to the plant as the root system penetrates deeper or spreads laterally. Figure 6 shows adequate and excessive levels of root nitrate-N during a growing season.

Root nitrate concentrations can help you determine the need for N fertilizer application. If root nitrate concentrations are high, you can delay or omit side-dress N applications. High root nitrate-N concentrations late in the growing season usually reflect available N supply in excess of crop needs. However, root nitrate-N concentrations also can be high if another factor limits growth.

Most research trials have not demonstrated a link between high root nitrate late in the season and bulb shrinkage and rot in storage. Environmental conditions such as hail, poor conditions for field curing, or high humidity early in storage play a larger role than crop N status in determining storage loss.

Postharvest N management

Crop rotations that include a deep-rooted crop following onions (alfalfa, sugar beets, or cereals) can assist in recovering some of the nitrate-N from below the onion root zone. Consult your local Extension agent on cover cropping options for your area.

Phosphorus

Assessing P needs

Phosphorus deficiency reduces bulb size and can delay maturation. Crop P uptake for a bulb yield of 840 cwt/acre was 20 to 25 lb P per acre in Columbia Basin research (Figure 3, page 7). Maximum P uptake rates are 0.3 to 0.5 lb per acre per day during bulb growth.

Consider the following soil and crop management factors when determining P fertilizer application methods and rates:

- Soil test value (ppm)
- Soil free lime (calcium carbonate) concentration
- Fumigation

Collect soil samples from the 0- to 12-inch depth for P analysis. Different soil test methods are used in testing for P availability on alkaline and acid soils. The Bray P1 test is appropriate for acid to neutral soils (pH < 6.5). The Olsen (sodium bicarbonate) method is appropriate at all soil pH values. Check with your laboratory if you are unsure about which test method they use.

Fumigation prior to seeding onions might increase P fertilizer requirements. Fumigation kills the mycorrhizal fungi that help onion plants take up P. (See "Root growth and development," page 4.) In a 2-year Treasure Valley trial (Figure 7), fumigation caused P deficiency at soil test values below 30 ppm P. Without fumigation, adequate P for maximum yield was present at a soil test value of 10 ppm.

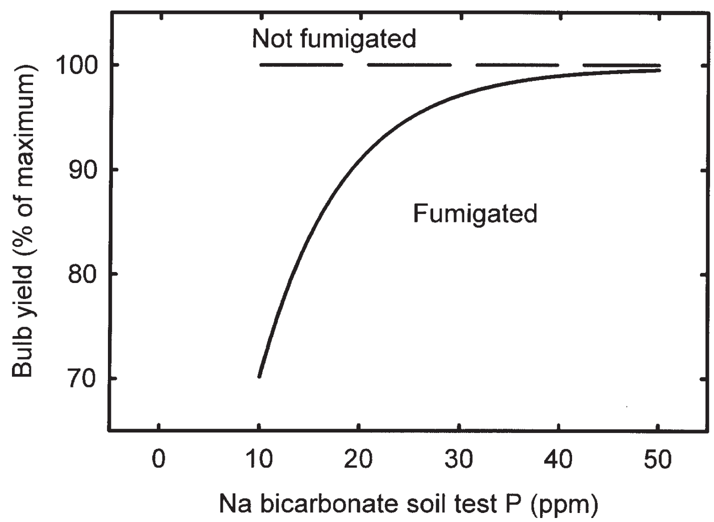


Figure 7.*—Fumigation increases the need for fertilizer P. Without fumigation, maximum onion yields were produced at 10 ppm soil test P (Olsen sodium bicarbonate extractant). With fumigation, onion yields increased with increasing soil test P up to 30 ppm. Soil at the test site contained about 10 percent lime. Source: Mike Thornton, University of Idaho Parma Research and Extension Center.*

Table 4 shows how soil and management factors affect P fertilizer requirements in the Treasure Valley. For other growing areas, research data for onions is more limited; consult a qualified agronomist for assistance.

Application methods

Incorporating P fertilizer in the planting bed is recommended. You can broadcast P prior to bedding or band it in conjunction with the bedding operation. Banded P fertilizer applications have been shown to be more effective than broadcast applications in western Oregon. Banding P below and to the side of the seed was no more effective than broadcast P in Treasure Valley trials. Do not place banded ammonium phosphates with onion seed because of the danger of ammonia toxicity.

Correcting P deficiency via foliar application is not recommended. Onion P requirements are very large compared to the amount of P that can be absorbed by leaf tissue.

Because of water quality concerns, minimizing P loss from the field is becoming an important consideration. Any practice that reduces furrow erosion will reduce total P loss from the field. You can reduce furrow erosion by a variety of methods, including laser

Table 4.—Phosphorus fertilizer rates based on soil test P, lime concentration, and fumigation for onions grown in the Treasure Valley.

Bicarbonate (Olsen) soil test P 0 to 12 inches	**Soil lime concentration (%)[a]**			
	0	**5**	**10**	**15**
(ppm)	P fertilizer application rate (lb P_2O_5 per acre)[b]			
	Not fumigated before planting			
0	160	200	240	280
5	100	140	180	220
10	40	80	120	160
15	0	20	60	100
20	0	0	0	40
above 25	0	0	0	0
	Fumigated before planting			
0	200	240	280	320
5	140	180	220	260
10	80	120	160	200
15	20	60	100	140
20	0	40	20	80
25	0	0	0	20
above 30	0	0	0	0

[a]Soil lime concentration as determined by calcium carbonate equivalent test.

[b]To convert from the oxide (P_2O_5) to the elemental form (P) multiply by 0.43.

Source: Brown, B. 2000. *Onions. Southern Idaho Fertilizer Guide*. CIS 1081. University of Idaho, Moscow, ID.

leveling, filter strips, sediment ponds, irrigation water management, straw mulching, and addition of PAM (polyacrylamide) to irrigation water.

Monitoring crop P status

Limited data exists to interpret crop P status via plant tissue testing. The range between deficient and adequate tissue P concentrations often is narrow because more plant biomass is produced when P deficiency is corrected. In a 2-year Treasure Valley trial, leaf phosphate-P (PO_4-P) was 3,000 ppm (dry wt. basis) in phosphorus-deficient onions, while in phosphorus-sufficient onions it was 3,300 ppm.

In the same trial, root PO_4-P concentrations necessary for maximum colossal production were 2,000 to 2,500 ppm at the 3- to 4-leaf stage and 1,600 to 2,000 ppm at the 8- to 9-leaf stage. Onions producing high yields at two Columbia Basin field locations had 1,500 to 3,500 ppm root PO_4-P during the growing season.

Potassium

Assessing K needs

Onions take up nearly equal amounts of N and K. A 700- to 1,100-cwt crop removed 110 to 160 lb K per acre in Columbia Basin trials (e.g., Figure 3, page 7), with peak uptake rates of 2 to 3 lb K per acre per day. Onions remove less K than potatoes and alfalfa.

Potassium is a positively charged ion that is held on exchange sites in soil. The potassium-supplying capacity of a soil usually is greater for soils with higher cation exchange capacity (CEC).

Potassium-deficient onions are relatively rare in the Treasure Valley. Potassium fertilization often is needed on the sandy soils that have a lower CEC in the Columbia Basin.

Laboratories determine available K status by extracting soils with sodium bicarbonate or ammonium acetate. Both extractants usually produce comparable soil test values and are considered equivalent. Soil test recommendations are based on a 0- to 12-inch sample. Table 5 shows the interpretation of soil test K from the *Southern Idaho Fertilizer Guide.*

Table 5.—Potassium fertilizer rates based on soil test K for onions grown in the Treasure Valley.

Potassium (K) soil test[a] 0 to 12 inches (ppm)	K fertilizer application rate	
	(lb K per acre)	(lb K_2O per acre)
0	200	240
50	100	120
above 100	0	0

[a]Soil test K as determined by sodium bicarbonate (Olsen) extraction.

Source: Brown, B. 2000. *Onions. Southern Idaho Fertilizer Guide.* CIS 1081. University of Idaho, Moscow, ID.

K fertilizer application

Potassium fertilizers are soluble salts. Apply K fertilizers only when needed, because excess salts can reduce seed germination and plant growth.

Potassium should be applied preplant on most soils. Incorporate it in the fall or during seedbed preparation. In-season application of K might be preferred on some very sandy soils in the Columbia Basin to avoid problems associated with excessive salts early in the growing season (see below).

Water stress and salinity

Onions are very sensitive to water stress. They respond to water stress with reduced rates of transpiration, photosynthesis, and growth. Water stress can be caused by soluble salts in the soil or by a soil water deficit.

During bulb growth, onions are more sensitive to water stress than most other crops. Water stress at this time reduces bulb yield and size. In Columbia Basin studies, water stress at the 3- to 5-leaf stage reduced the percentage of single-centered bulbs by 40 to 60 percent compared to nonstressed onions.

Drip irrigation systems can be managed to maintain consistent soil moisture during bulb development.

In Treasure Valley research with drip-irrigated onions, maximum bulb yield and size were achieved by maintaining soil moisture near field capacity at the 8-inch depth (a soil water potential of about –20 kPa, a reading of 0.2 bars or 20 centibars on a tensiometer). Maintaining soil water potential at –25 kPa requires 11 to 20 furrow irrigations during the growing season in the Treasure Valley, depending on seasonal precipitation and evapotranspiration.

Fertilizers incorporated into planting beds before seeding increase soluble salts. High levels of soluble salts can kill seedlings as they emerge. Onions can tolerate higher salt levels after plants are established. Screening tests for salinity tolerance show that yield reduction begins to occur at a conductivity of 1 to 2 mmhos/cm, and a 50 percent yield reduction occurs at 4 to 5 mmhos/cm.

Salinity problems also can include toxicity of specific elements such as boron or sodium. Boron and sodium toxicity usually are related to irrigation water quality. Extension vegetable crop specialists in California report that onions are more sensitive to salinity, sodium, and boron than are lettuce, cauliflower, broccoli, and cabbage.

Monitoring crop K status

Insufficient data exists to make fertilizer recommendations based on plant tissue K levels. At two adequately fertilized sites in the Columbia Basin, onion leaf tissue contained 2.5 to 3.5 percent K (dry wt. basis) at the 3- to 8-leaf growth stage, and root K concentrations ranged from 3 to 5 percent (dry wt. basis) during the growing season.

Calcium and magnesium

Research on the effects of calcium (Ca) or magnesium (Mg) application on onion bulb yield and quality is very limited.

Onion bulbs usually contain about 0.5 percent Ca (dry wt. basis), and crop uptake averages 50 lb per acre. One trial in the Treasure Valley with added Ca as calcium nitrate showed no response in bulb yield or quality. Higher plant Ca uptake sometimes occurs when calcium nitrate fertilizers are applied (e.g., uptake of 120 lb Ca per acre in Figure 3, page 7). Low Ca supply can be a concern on very sandy Columbia Basin soils with low pH values. (See “Acid soils in the Columbia Basin,” page 15.)

Onion bulbs contain approximately 0.10 to 0.15 percent Mg (dry wt. basis). Crop Mg uptake ranged from 10 to 20 lb per acre in several Columbia Basin field trials (e.g., Figure 3, page 7).

Sulfur

Assessing S needs

Sulfur is an essential plant nutrient and it contributes to the distinctive flavor of onions. Volatile sulfur compounds are released by action of the enzyme allinase when onions are cut or bruised. Onion varieties differ in the amount and kinds of S compounds present in the bulb.

Some of the S compounds responsible for pungency can inhibit the growth of fungi and bacteria and have been shown to reduce storage losses of sweet, short-day onions grown in Georgia. Application of S fertilizer increased onion pungency in Treasure Valley trials, but did not affect bulb storage loss. Increased bulb pungency is a negative characteristic in marketing of most onions.

Onion bulbs contained 0.3 to 0.6 percent S (dry wt. basis) in Columbia Basin trials. The N to S ratio in bulbs ranged from 3 to 1 to about 5 to 1. An 840 cwt/acre crop removed about 35 lb S per acre (Figure 3, page 7). Maximum S uptake rates were 0.6 to 0.9 lb S per acre per day during bulb growth.

Sulfur fertilization is not needed in many locations because adequate S is supplied from other sources. Nonfertilizer sources of S include:

- Preplant soil sulfate-S
- Decomposition of crop residues and soil organic matter during the growing season
- Irrigation water

Soils containing lime can precipitate and store S as gypsum (calcium sulfate). Gypsum accumulated in the top 2 feet of soil serves as another source of plant-available S.

The preplant sulfate-S soil test is less reliable for prediction of plant responses to fertilizer S than soil tests for N, P, and Zn. Collect preplant soil samples for sulfate-S to a 24-in depth. Use the same soil samples collected for preplant nitrate-N analysis. (See “Preplant soil nitrate-N,” page 7.)

Fertilizer application

Apply sulfur fertilizers if soil test values for sulfate-S are less than 5 ppm (mg/kg) and irrigation water sulfate-S is less than 5 ppm (mg/L). Apply 30 to 40 lb S per acre when soil and irrigation water tests indicate a need. Apply soluble S sources just prior to or during the period of rapid crop uptake (Figure 3, page 7) for maximum efficiency.

Sulfur salts such as potassium sulfate or ammonium sulfate can supply S. Do not apply ammonium thiosulfate near onion roots. Ammonium thiosulfate usually has a high pH (8) and contains some ammonia, which is toxic to roots. The thiosulfate ion itself also is toxic to roots. After a few days or weeks in soil, ammonia is converted to nontoxic ammonium-N, and thiosulfate is converted to nontoxic sulfate-S.

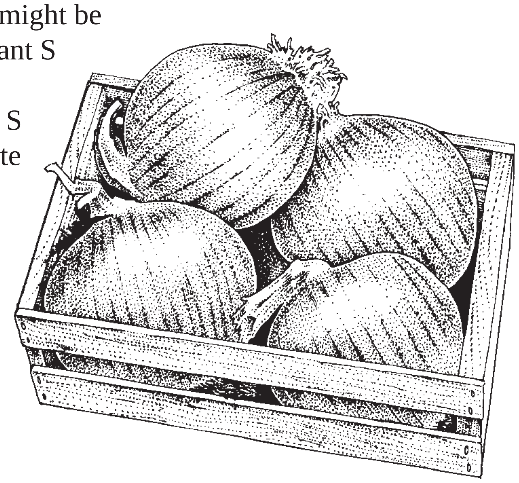
Urea-sulfuric acid supplies available S and N. It also increases soil acidity (lowers pH). The lower pH produced by urea-sulfuric acid application might temporarily increase availability of Zn on high-pH calcareous soils (those that contain carbonate or lime). It also might increase soil acidity problems on very sandy Columbia Basin soils. (See “Acid soils in the Columbia Basin,” page 15.)

Monitoring crop S status

Limited data exists to interpret plant tissue tests for S. Total S in leaves and roots (3- to 8-leaf growth stage) ranged from 0.5 to 0.8 percent (dry wt. basis) for adequately fertilized onions in Columbia Basin trials. Onions supplied with low amounts of S in greenhouse trials had leaf S concentrations of less than 0.4 percent during bulb growth.

Root or bulb SO_4-S might be a useful indicator of plant S status. Bulb sulfate-S increased linearly with S fertilizer application rate in a recent greenhouse study with ‘Southport White Globe’ onions.

Total bulb S is a poor indicator of pungency. Onion varieties differ in the kinds and amounts of sulfur compounds present in bulbs.



Micronutrients

Onion uptake of micronutrients is most rapid during bulb growth (Figure 3, page 7). Applications of micronutrients are not recommended unless a reliable soil or plant tissue test indicates a need. Data to interpret soil and plant tissue tests for onion micronutrient status is limited. Most interpretations are based on response data from other crops. Research on onion response to Zn and B has been conducted in the Treasure Valley.

You can use soil tests to assess the potential for micronutrient deficiencies and toxicities. The DTPA soil test evaluates deficiencies of zinc (Zn), manganese (Mn), and copper (Cu). The hot-water and sorbitol extraction methods assess soil B availability. You can use leaf tissue tests to monitor total plant tissue concentrations of Zn, Mn, Cu, molybdenum (Mo), and boron (B).

Onions are sensitive to zinc deficiency. Deficiencies usually occur on white, high lime subsoils that have been exposed by land leveling or erosion. Soils are considered marginal at 0.8 to 1.0 ppm DTPA extractable Zn. Deficient Zn concentrations in leaf tissue probably are 10 to 20 ppm (dry wt. basis), based on data from other crops. Zinc deficiency can be corrected by soil or foliar Zn applications. There is insufficient data to support specific recommendations.

Application of manure or compost to other crops in rotation with onions might reduce or eliminate deficiencies of Zn and other micronutrients in onions. Manure or compost application prior to seeding onions generally is not recommended. Salts from manure or compost might reduce seed germination and increase water stress.

Onions did not respond to applied boron in Treasure Valley field tests even at low soil test levels of hot-water extractable boron (less than 0.5 ppm). Sufficient soil B levels on low organic matter, sandy soils in the Columbia Basin are about 0.3 ppm. If soil or plant tissue tests indicate a potential B deficiency, apply B fertilizer at low rates. Boron toxicity can occur if B is excessive. There is insufficient data to support specific recommendations.

Molybdenum (Mo) deficiency might occur on recently acidified, sandy soils in the Columbia Basin. Onions with leaf tissue Mo concentrations of less than 0.15 to 0.30 ppm (dry wt. basis) might respond to Mo application.

No research has been performed to assess manganese and copper response in onions grown in the Columbia Basin or the Treasure Valley.

Iron deficiency of onions has not been documented in the Pacific Northwest. DTPA soil tests and plant tissue tests for iron are not as reliable as those for other micronutrients. Trial applications of foliar iron might be warranted when soil pH is above 8.5. Soil applications of iron generally are ineffective in high pH soils.

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