

# Onions



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The following fertilizer guidelines are based on University of Idaho research relating the yield and grade response of onions to soil tests and fertilizer applications. The suggested fertilizer rates are designed to produce above average yields if other factors are not limiting production. Thus, it is assumed that good management practices are used and that there are no other limitations to production. Good weed, disease, and insect control can significantly increase fertilizer effectiveness.

The suggested fertilizer rates also assume that soil samples are properly taken and processed, and that they represent the area to be fertilized. Many fields have appreciable variation in residual nutrient soil tests and/or productivity. Areas within fields that differ significantly in residual fertility or productivity should be sampled and treated separately if large enough to accommodate conventional commercial or variable rate application equipment. Accurate crop history information is also essential for the suggested rates to be appropriate.

## Nitrogen

Optimum nitrogen (N) is necessary for maximum economic production of onions. Nitrogen is usually the greatest expense of all the fertilizer costs. Nitrogen affects not only bulb yield but bulb grade or quality, maturity and storability, and disease resistance. Shortages of N reduce both total yield and bulb size or marketable yield. A nitrogen shortage also delays maturity as measured by the percentage of tops down and may increase the shrink in storage.

Excess N may also reduce yield and quality. Excessive N applied preplant and shallowly incorporated can reduce stands and contribute to additional weed growth and competition. Excessive sidedressed N can adversely

affect growth, especially high rates of urea N. Excessive N available late in the season can also delay maturity, and the maturity delay can contribute to increased storage shrink.

## Total N Required

Onions require from 50 to 150 pounds N per acre as inorganic soil test and fertilizer N based on N rate studies conducted in southwestern Idaho. The N requirement varied due to many of the factors mentioned below. Onion yields ranged from 500 to 1,100 hundred-weight (cwt) per acre in these studies.

The amount of N required depends on many factors that influence total and marketable production and quality including the following factors:

- Plant population
- Leaching losses from excessive irrigation or rainfall
- N carryover from the preceding crop
- Preceding crop residue returned to the soil
- Mineralizable N released from soil organic matter

The N content of onions ranged from 80 to 150 pounds per acre in fields where onion stands ranged from 70 to 95 percent in recent studies. Poor stands reduce the N requirements for onions. Onion N content was directly proportional to onion stands. Onion N content was reduced about 18 pounds per acre for each 10 percent reduction in stand from 100 percent. Therefore, growers should reduce the N requirement for poorer stands by 15 to 20 pounds N per acre for each 10 percent reduction in stand below 90 percent.

Onion varieties that differ markedly in yield potential can be expected to differ somewhat in their requirements for N. Higher yielding varieties may require slightly more N.

The N from all sources (soil test, previous crop, mineralizable N, and irrigation water) should be considered when determining N fertilizer rates to use.

## Nitrogen Soil Test

The residual soil inorganic N ( $\text{NO}_3$ ,  $\text{NH}_4$ ) can be evaluated with a soil test (saturated gypsum extraction). Potassium chloride can be used for extracting  $\text{NO}_3$ , but  $\text{NH}_4$  values will be inflated two to three fold as compared to a saturated gypsum solution. Soil samples should be collected in foot increments to a depth of two feet, unless roots are restricted.

Ammonium N ( $\text{NH}_4$ -N) is generally low in preplant soil samples and, in these cases, contributes little to the available N sum. But it can be as high or higher than  $\text{NO}_3$ -N.  $\text{NH}_4$ -N should be determined along with  $\text{NO}_3$ -N especially when there is reason to expect appreciable  $\text{NH}_4$ -N present (e.g., late fall or recent ammonium N fertilizer applications).

To convert soil test  $\text{NO}_3$ -N and  $\text{NH}_4$ -N values to pounds N per acre, total the N values expressed in ppm for each foot increment of sampling depth and multiply times 4.0. An example is shown in Table 1.

**Table 1. Soil test N conversion example.**

Depth (inches)	$\text{NO}_3$ -N (ppm)	$\text{NH}_4$ -N (ppm)	Sum (ppm)	Inorganic N <sup>1</sup> (lb/acre)
0 to 12	5	2	7	28
12 to 24	3	1	4	16
Total	8	3	11	44

<sup>1</sup>ppm x 4 = lb per acre

In many cases a preplant soil sample is only collected from the 0 to 12-inch depth. Although the information is not as complete and reliable as deeper sampling would provide, residual N measured only from the first foot can be used for predicting onion N requirements. Preplant soil test  $\text{NO}_3$ -N for onions in southwestern Idaho is commonly only one half to two thirds as high in the second foot as it is in the first foot. This may not be the case with significant leaching over winter or following potatoes or other sprinkler irrigated crops, especially in coarser textured soils. Otherwise, if only a 0 to 12-inch sample is collected, assume the inorganic N measured in the first foot is two thirds of the total.

Fall soil samples are frequently collected before fall fertilizing and bedding fields to be used for onions the following spring. Whereas fall collected samples may indicate the needs for non-mobile nutrients such as phosphorus, potassium, and zinc, fall collected samples should not be used to indicate inorganic soil N available the following season. Any  $\text{NO}_3$ -N measured in fall collected samples is subject to leaching, denitrification, and immobilization before planting onions the following spring. A fall collected sample also will not reflect the N mineralized since the sample was collected. In short, it will not reflect the previous crop influence as well as preplant samples in the spring.

## Previous Crop

Nitrogen associated with decomposition of previous crop residues should also be considered in estimating available N. Residues that require additional N for decomposition include cereal straw and mature corn stalks, particularly if incorporated into soils late in the fall. Research has shown up to 15 pounds N are needed per ton of cereal residue returned to the soil up to a maximum of 50 pounds when residues are incorporated late fall. For more information on compensating for cereal residues refer to University of Idaho publication CIS 825, *Wheat Straw Management and Nitrogen Fertilizer Requirements*.

Non-cereal crop residues (potatoes, sugarbeets, onions, beans, mint, and sweet corn) do not require additional N for decomposition. The N contributions from these residues are largely reflected by the spring N soil test because the residues are more easily decomposed and/or are incorporated in summer to early fall.

Alfalfa residues (both forage and seed) can release appreciable N for onions during the following crop season that may not be reflected by the preplant soil test. This N is derived from the decomposition of both alfalfa tops, which are rapidly decomposed and roots or crowns that decompose more slowly.

Alfalfa seed residues involve less root mass than forage alfalfa due to greatly reduced plant populations, but the amount of foliage returned to the soil may be higher than with forage, depending on the alfalfa forage re-growth after the final cutting. The N released from alfalfa seed residues would consequently be more reflected by the spring preplant N soil test than would forage alfalfa residues. Tillage hastens the breakdown of these residues and the associated N release.

Other residues such as sweet corn can also provide significant N for the next onion crop. Fresh sweet corn residues tend to be higher in N than mature sweet corn seed or field corn stalks, are less lignified, are incorporated earlier, and result in a net release of N the following season. Fields receiving spent mint hay may also release significant quantities of N during the following season for onions depending on the amount incorporated into the soil.

Table 2 estimates the net N contribution from previous cropping that can be used to adjust the N rate for onions.

## Mineralizable Nitrogen

Soils vary in their capacity to release N from organic matter during the growing season. The amount of N released depends on such factors as soil type, soil moisture, soil temperature, previous crop, and the history of fertilizer N applied. Soils that retain moisture

**Table 2. Estimated N effect from previous crop on the N requirement.**

Previous crop	lb N per acre
Grain or corn (residue returned late fall) <sup>1</sup>	50
Grain (residue/volunteers returned early fall) <sup>2</sup>	25
Grain or corn (residue removed)	0
Row crops (potatoes, sugarbeets, onions, sweet corn, beans, peas, mint)	0
Alfalfa seed	-30
Alfalfa	-60

<sup>1</sup>Assumes little or no volunteer small grain growth.

<sup>2</sup>Assumes small grain field was watered, volunteers emerged by mid-September, and all plant material incorporated by Oct. 1.

tend to mineralize more N than soils such as sandy loams, which dry out more rapidly. Mineralization of N is limited by cooler soil temperatures that limit soil biological activity.

Previous crop residues, when incorporated, appreciably affect N mineralization depending on the total amount involved and their carbon to nitrogen ratio. Some residues such as mature corn stalks and small grain residues will tie up N and cause a net loss of available N for onions.

Measurements of mineralizable N for onions following wheat typically ranged from 35 to over 145 pounds per acre in recent studies and averaged about 70 pounds per acre. The N mineralized for onions following other crops can be much higher. In one case of onions following mint, where several tons per acre of mint residues were returned to the site, N mineralized was as high as 420 pounds per acre.

Recent studies show that mineralized N is released primarily during onion bulbing when onion root systems are well developed and the onions are taking up N at maximum rates. Mineralized N then is used as efficiently as fertilizer applied N.

There is no widely accepted soil test used for estimating mineralized N in commercial labs. Soil organic matter content is frequently used to estimate mineralizable N contributions, but it fails to accurately predict mineralizable N in southern Idaho irrigated soils. Until a convenient and accurate test is available for estimating mineralizable N it will be difficult to use estimates for adjusting N fertilizer rates. Knowing the contributions from more easily measured sources of N for onions will have to suffice until then.

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*Note:* The N rate recommendations in this guide reflect normal background amounts of mineralizable N but do not include N mineralization estimates specifically in the calculation of the N rate to apply.

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## ***Irrigation Water***

Irrigation waters derived from deep wells are generally low in N. Irrigation waters from most districts are also low in N when diverted from its source. Background levels of N from original sources are generally about 2 parts per million (ppm). The more return flow included in diverted water sources, the higher the N content. Return flows may include N dissolved when irrigation waters pass through fields high in residual or recently added fertilizer N as well as from soluble fertilizer N applied with the irrigation water.

Most irrigation districts should know the N content of the water they divert. Contact them for this information to determine the levels of N added with your irrigation water. However, since irrigation water N levels are influenced by upstream management, if you use irrigation water that receives runoff after it is diverted, only a water test can accurately evaluate the N added with irrigation waters.

For each ppm or milligrams per liter (mg/L) of N reported in the water sample, multiply by 2.7 to get the N added per acre foot of water applied. For example, if the water sample contained 10 ppm of N, 3 acre feet of water applied would be the equivalent of 81 pounds of N per acre. Typically, of the water applied with furrow irrigation only 50 percent is retained on the field and the rest runs off the end. The net retention of N applied with furrow irrigation would, therefore, be about half of the water applied or about 40 pounds per acre in this example. If more or less of the irrigation water is retained with each wetting, then growers should adjust the water N contribution accordingly.

Excessive irrigation by any method reduces N availability to onions. Additional N may be needed under these conditions. Growers should not use aqua or anhydrous N through a sprinkler irrigation system.

Water running soluble N sources with a furrow irrigation system can be an effective means of adding N. Two limitations of this practice are that (1) the application of N with this method may not be as uniform as desired and (2) runoff containing the N may contaminate downstream surface waters. Growers can minimize the loss of N by shutting off the injection unit before the irrigation water reaches the end of the furrow. This practice should not substitute for careful consideration of N needs while N can be sidedressed.

Drip irrigated onions typically are fertilized with N through the drip system. Results from local research suggest that N is used more efficiently with this system as compared to conventional irrigated and fertilized onions. The greater efficiency likely results from less N leached beyond the root system and the positioning of N within the root system.

Since N with drip irrigation is concentrated more within the root system, onions may also be more susceptible to excessive applied N. Using N rates commonly used for furrow irrigated onions, even if the N is injected periodically, can result in excessive N that reduces yield, quality, or storability. Growers should distribute N through drip lines throughout the season, but the rate should not exceed the actual requirements during specific growth stages and also should reflect the residual N already present. For information on N uptake by onions refer to Oregon State University PNW 513, *Nitrogen Uptake and Utilization by Pacific Northwest Crops*.

### Manures

Very few soils used for onions receive manures. If manures are used, nitrogen contributions from manures should be considered when estimating available N for the next season. Manures can preclude the need for any fertilizer depending on the rate applied and their nutrient composition.

Manures can vary appreciably depending on the animal, how the manure is processed, and the kind and amount of bedding material included. For the most accurate estimate of fertilizer equivalent values onion growers should analyze the manure for its nutrient content. For more detailed information on animal manures and their nutrient contributions to soils refer to Washington State University PNW 239, *How to Calculate Manure Application Rates in the Pacific Northwest*.

### Estimating the N Application Rate

The N application rate is estimated from (1) the total N requirement for onions (excluding mineralized N) of 160 pounds per acre, (2) an adjustment due to the previous crop effect, (3) available soil N as measured by spring preplant soil test N, and (4) irrigation water N. The total N requirement does not include the contribution from mineralized N since that estimate is not conveniently measured or known. An example is shown in Table 3 using the soil test N from Table 1, a previous crop of wheat with residues incorporated late summer, and relatively clean irrigation water with only 2.5 ppm nitrate-N and 50 percent soil retention of the 3 acre feet applied.

**Table 3. Calculation of N application rate.**

		(lb N per acre)
N requirement		160
Soil test N	(Table 1)	-44
Previous crop	(Table 2)	25
Irrigation water		<u>-10</u>
N rate to apply		131

### Timing of Nitrogen Application

Onions use very little N (less than 5 percent of the total requirement) before bulb initiation and then use from 1.2 to 1.7 pounds N per acre per day during rapid bulbing, depending on the stand and other factors influencing yield.

Fall applied N is susceptible to over winter leaching, denitrification, and microbial immobilization. Preplant applied N (including fall applied N) is not used as effectively as N sidedressed after onions are well established and the root system has begun to develop. Spring preplant or very early season applied N is easily moved beyond the limited root system with the first one or two furrow irrigations. This hazard exists on all soils but particularly on coarse textured soils such as sands, sandy loams, etc.

For growers to satisfy the minimal early season N requirements of onions under very low available N conditions, they should apply ammonium N in fall beds after soil temperatures fall below 50°F. Low N rates of 20 to 30 pounds per acre should be adequate to support early season onion growth provided the N is not lost to leaching, denitrification, or immobilization. Concentrated bands of ammonium N below and to the side of the onion row may provide some protection against N leaching, microbial immobilization, and promote less weed competition than broadcasted and shallow incorporated N. Minimal N may also be sidedressed on the furrow side of bed shoulders in the early spring. Avoid moderate to high N rates as onion seedlings are susceptible to excessive fertilizer salts and free NH<sub>3</sub> from urea based N sources.

A higher percentage of fertilizer N is absorbed and used by the plant if the fertilizer is applied when the onion root system is well developed. Split applications of N are used more effectively by the plant than a single preplant application. The N sidedressed at bulb initiation avoids the leaching hazards of fall or early season applied N and a well developed root system can take maximum advantage of the N provided. Do not use high rates (>100 lb N/acre) applied as urea in single applications due to the risk of NH<sub>3</sub> toxicity.

Certain delayed or slow release N sources banded preplant or early in the season on bed shoulders have proved as effective as split applied N for onions. But not all materials available have been screened and shown to be effective. Basically, materials that result in most of the N becoming available just before or during bulbing should prove as effective as split or delayed single applications of N. These materials tend to be considerably more expensive than conventional N fertilizers, and the relative economics of their use has not been fully determined. For an example of onion response to slow

release N refer to University of Idaho Bulletin 683, *Sulfur-Coated Urea as a Slow Release Nitrogen Source for Onions*.

### Bed Center Irrigation

Nitrate-N accumulates in bed centers with repeated furrow irrigation of outside furrows as the wetting front reaches the middle of the beds. Bed center nitrates are less available to onions at early growth stages when the root system has yet to extend to the middle of beds. With development of the root system, roots will extend to the accumulated nitrates.

Some onion growers may try and flush this accumulation back toward the onion row by irrigating the bed center. This practice can be effective in increasing the use of N from bed centers but is not without risks. The N directly below and adjacent to the bed center furrow is subject to leaching. While some nitrate-N may be flushed back toward the onion row, lengthy irrigation sets and deep wetting can result in loss of N beyond the reach of the onion roots. The N moved beyond the root system is then susceptible to even deeper movement with subsequent irrigation or over winter precipitation.

To maximize use of N growers should avoid excessive irrigation that results in the joining of the wetting fronts from both sides of the bed. The joined wetting fronts will result in nitrates accumulating in the first 2 inches of the surface where there are few onion roots and poor utilization.

Onion root systems in fully developed plants extend across the entire bed at depths below about 2 inches with conventional 22-inch row spacings. Thus, onions can use bed center N deeper than 2 inches as long as the root system later in the season is healthy and developed enough to extend to the middle. If the nitrates are excessive when onion roots reach bed centers, onion yield and storability may be adversely affected.

Bed center nitrate accumulations can be minimized by (1) reducing the amount of N applied in excess of the onion N requirement during early growth stages and (2) irrigating such that the wetting front does not extend beyond the developed root system.

## Phosphorus

Phosphorus (P) deficient onions appear stunted and are slower to develop. They may not otherwise exhibit obvious symptoms. Onions have relatively small root systems that are less efficient in accessing soil P. Onions are normally more affected by shortages of P during early growth stages because root systems are limited and cool soil temperatures reduce P diffusion or movement to root surfaces.

Minimum soil levels are necessary for maximum production. Soil tests can indicate whether soils require P fertilization for maximum onion production. Soil samples are collected in the fall or spring preplant from the 0 to 12-inch depth. Spring samples may be slightly higher in soil test P than fall collected samples.

Lime content of soil interacts with fertilizer P to reduce its effectiveness. Fertilizer P rates should be increased as soil lime increases.

Fall fumigation reduces the ability of onions to obtain soil P resulting in stunting of onions and reduced yields in soils that are marginal to low in P. High lime soils are particularly susceptible. Fumigation can reduce beneficial mycorrhizal fungal associations that effectively increase root extension. Hyphae of the mycorrhizae extend further into soil and take up nutrients that are shared with the onions. Onions are heavily dependent on mycorrhizae under limited P conditions. When soil test P is adequate the fungal association is much less important and there may be little if any beneficial infection of roots by the mycorrhizae. Fumigation induced stunting of onions is generally not observed in soils with adequate soil P. But higher soil test P is required for fumigated soils. Phosphorus recommendations based on soil test P, lime content, and fumigation are shown in Table 4.

Broadcast with incorporation or banding below the rows during bedding are effective methods of application. Banding high rates of P with the seed during seeding, especially ammonium phosphate fertilizers, can cause seedling damage. Surface broadcast applications without incorporation are not recommended.

**Table 4. Phosphorus fertilizer rates based on soil test P, lime content, and fumigation.**

Soil test P <sup>1</sup> 0 to 12 inches (ppm)	Lime content <sup>2</sup> (%)			
	0	5	10	15
	Non-fumigated			
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
25	0	0	0	0
	Fumigated			
0	200	240	280	320
5	140	180	220	260
10	80	120	160	200
15	20	60	100	140
20	0	0	40	80
25	0	0	0	20
30	0	0	0	0

<sup>1</sup>NaHCO<sub>3</sub> extraction (sodium bicarbonate).

<sup>2</sup>Lime content is measured as calcium carbonate equivalent.

<sup>3</sup>To convert from the oxide (P<sub>2</sub>O<sub>5</sub>) to the elemental form (P) multiply by 0.43.

## Potassium

Onions require medium concentrations of available soil potassium (K). The potassium soil test is based on potassium present in the surface soil. The recommended depth of sampling is 0 to 12 inches. Potassium deficient onions are relatively rare in southern Idaho.

Soil test K can be a useful indicator of the need for K. Table 5 gives K rates based on the K soil test. Samples should be collected in the fall or spring preplant. Fertilizer K should be plowed down or incorporated during seed bed preparation.

**Table 5. Potassium fertilizer rates (lb K<sub>2</sub>O per acre) for onions based on soil test.**

<b>K soil test<sup>1</sup> 0 to 12 inches</b>	<b>Application rates</b>
(ppm)	(lb K <sub>2</sub> O per acre) <sup>2</sup>
0	240
50	120
100	0

<sup>1</sup>NaHCO<sub>3</sub> extraction.

<sup>2</sup>To convert from the oxide (K<sub>2</sub>O) to the elemental form (K) multiply by 0.84.

## Sulfur

Sulfur (S) is also necessary for maximum onion production, but excess S can increase onion pungency, which may be undesirable for fresh marketing and consumption. Sulfur requirements for onions will vary depending on soil texture, leaching losses, S content of the irrigation water, previously used fertilizers and amendments containing S, and in some cases the S soil test. The S soil test in the first 12 inches is less reliable than soil tests for N, P, and zinc (Zn).

Few soils in southwestern Idaho are S deficient. The soils either have native residual S or have received appreciable S from fertilizers (ammonium sulfate, potassium sulfate), irrigation waters, or amendments used for reclamation purposes (gypsum, elemental S).

In western Idaho, the S content of much of the irrigation water is high enough to satisfy the S requirements for onions. Onions irrigated with Snake River water or waters consisting of significant runoff from other fields should not experience S shortages. Boise, Payette, and Weiser river water diverted above significant return flow may have relatively low S and contribute little S to irrigated soils. Some well waters may also be low in S and contribute little S. A water analysis can be used to estimate S contributed with irrigation water. If both the soil test (<5 ppm) and water test (<5 ppm) are

low in S add 40 pounds S per acre if S is not contained in other fertilizers.

Sulfur in the surface 12 inches is easily leached to lower depths, but unlike other mobile nutrients such as NO<sub>3</sub>-N, it may precipitate with calcium at lower depths to form gypsum. Precipitated gypsum prevents the further leaching of S and serves as a reservoir of S for onion roots extending into the second foot. Consequently, soils should be sampled to a greater depth for S (24 inches, similar to N) than for immobile nutrients such as P or K.

## Micronutrients

Onions are sensitive to low zinc (Zn) levels in soils. Apply zinc fertilizer when a soil test shows zinc in the 0 to 12-inch depth is below 0.6 ppm. Areas where land leveling has exposed white, high lime subsoil are often the most likely to respond to zinc applications. When soils are low apply zinc fertilizer at a rate which will supply 5 to 10 pounds of zinc per acre.

“Shotgun” applications of other micronutrients in mixtures containing boron (B), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), and nickel (Ni) are sometimes added to onions for “insurance.” These applications have not been shown to be economical and are not recommended.

Boron soil test values are frequently low (<0.5 ppm) in western Idaho, but the soil test for B is a poor indicator of B needs based on local research.

Onion growth response to micronutrients other than zinc have generally not been observed in irrigated southern Idaho soils. Even in severely scraped or eroded soils, other nutrients tend to be more limiting to yield than micronutrients. Applications of micronutrients are generally not recommended unless a need is indicated by a reliable soil or plant tissue test.

## Publication Orders

For copies of publications mentioned earlier contact the University of Idaho Cooperative Extension System office in your county or Ag Publications, University of Idaho, Moscow, ID 83844-2240, phone 208/885-7982, email: cking@uidaho.edu

How to Calculate Manure Application Rates in the Pacific Northwest, PNW 239 (25¢)

Nitrogen Uptake and Utilization by Pacific Northwest Crops, PNW 513 (\$2.50)

Sulfur-Coated Urea as a Slow Release Nitrogen Source for Onions, BUL 683 (50¢)

Wheat Straw Management and Nitrogen Fertilizer Requirements, CIS 825 (\$1.00)

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