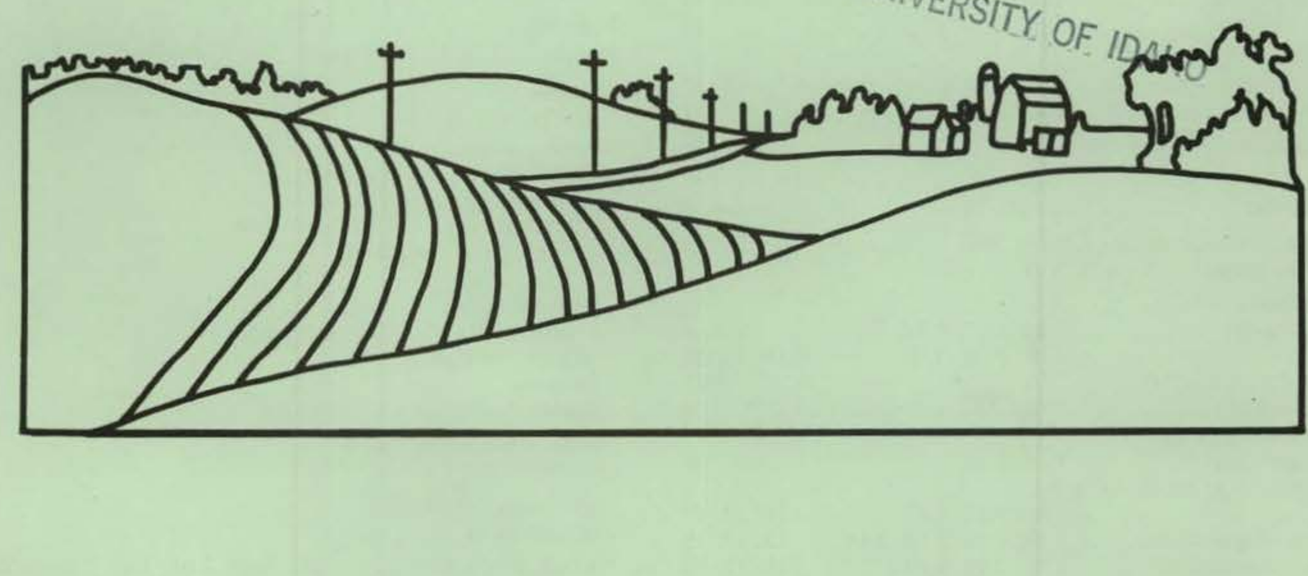
Bulletin No. 686

# Fertilizer Questions





Cooperative Extension Service
University of Idaho
College of Agriculture

# Index

# Fertilizer Questions

*Raymond G. Gavlak, Extension Soil Scientist*

## Forward

This publication lists many frequently asked questions about fertilization and fertilizers. Brief answers to those questions have been compiled from numerous sources and are included in the bulletin. Dr. Paul Kresge, adjunct professor, Montana State University, and Dr. Jim Bauder, Extension soil scientist, Montana Cooperative Extension Service, are credited with authorship of one source publication (Bulletin 1269, Fertilizer Questions, published cooperatively by Montana State University Cooperative Extension Service and North Dakota State University). Material from a similar publication by the Soils Branch of Alberta Agriculture (Agdex 520-1) has been included.

A difficult task is to condense years of research, and in some cases conflicting points of view, into one or two paragraphs. This approach, however, has proven popular as a starting point for the decision making process continually faced by growers and fertilizer dealers.

The material in this publication should be used for quick reference. Other sources and references should be investigated for more detailed answers about a particular subject. Specific topics are indexed alphabetically on the facing page.

# Table of Contents

# Section 1. General Soil Fertility

## 1.01

Q. I have a limited amount of money. Where is the best place to cut back on fertilizer?

A. There is no "best place" to cut back. Fertilizer is not a luxury item but an input capable of producing high returns.

However, if your banker is still not convinced, be sure to apply the full recommended amount to your most productive land. Cutting back should be done on the least productive land rather than "across the board." Marginal land doesn't return as much per dollar invested in fertilizer as does your best soil.

Be sure to have the soil tested to assure accurate fertilizer recommendations. Other action you may want to consider is:

1. Use anhydrous ammonia or the cheapest form of nitrogen available, rather than paying a premium for specially formulated N-containing products.
2. Eliminate use of nutrients that have not produced responses in past or that are not identified as needed by soil test results.
3. Under non-irrigated conditions, reduce fertilizer inputs in fields with the least soil moisture.
4. Don't fertilize at rates to achieve maximum potential yield but rather at rates approximately 5 to 10 percent below that level. This practice is likely to bring maximum net return per dollar spent on fertilizer.

## 1.02

Q. Are fluid fertilizers more available to the plant than dry materials?

A. No. Fluid (clear liquids and suspensions) and dry fertilizers go through the same reactions in the soil and are equally available to the plant. Dry fertilizers quickly dissolve in the water in the soil (soil solution) and behave the same as fluids. If the soil does not have sufficient water to dissolve dry fertilizer, it doesn't have sufficient water for plant growth with any nutrient source.

The decision to use dry or fluid fertilizer should be based on cost of the material, storage, handling, application and ease of use.

## 1.03

Q. What are the advantages of banding fertilizer?

A. Banding can mean many things. Usually banding is considered to be the process of placing fertilizer in the soil in a concentrated zone. Banding may be done with seed or near the seed at planting. Bands of fertilizer may also be placed in the soil at times other than seeding. This is often referred to as deep banding or side dressing. Some recent work has also been done with surface bands, or strips of fertilizer on the soil surface.

The objective of banding is to improve fertilizer efficiency. This may be due to the effects of placing fertilizer close to the seed. Fertilizer placed with seed may improve early plant growth and lead to a more vigorous plant under cold, wet soil conditions. Concentrating fertilizer, especially phosphorus, in a band may reduce adverse soil reactions and allow the phosphorus to remain more available for a longer period of time depending on the material used. Deep banding may also keep the fertilizer in moist soil for a longer period of time thus enhancing uptake.

## 1.04

Q. Why have organic matter levels been decreasing in most of our dryland soils?

A. Cultivation and summer fallowing have contributed greatly to the decline in organic matter. Summer fallowing increases soil temperature, soil water and aeration, which hastens decomposition of organic matter. Nitrogen has been released from the soil by this process for several decades. Decomposition of organic matter causes soil nitrate levels to be higher following a fallow year than in a recrop situation. Switching from crop-fallow to continuous cropping will cause soil organic matter in some soils to build back up over a period of time.

Organic matter level has not necessarily been reduced under irrigation. Many growers using irrigation have experienced no changes or modest increases in organic matter levels. This is probably due to increased residue return as cropping intensity increases with irrigation.

## 1.05

Q. Will burning stubble or other crop residue be harmful to the soil?

A. Yes. Long term effect of burning is to reduce soil organic matter. Although this aspect is difficult to express in dollars, the results are increased tillage energy requirements, more soil erosion, lower soil water and nutrient storage capacity and generally deteriorated soil physical properties. Burning stubble may have some advantages over the short run, i.e. fewer weeds, increased mineralization of organic nitrogen and less tie-up of fertilizer nitrogen. In addition to adversely affecting soil, burning causes nitrogen and sulfur contained in residue to be converted to gases and lost. A dollar value can certainly be placed on the nitrogen lost.

## 1.06

Q. Is nutrient leaching a problem?

A. The answer depends on the nutrient and situation. Phosphorus is very immobile in the soil, so it doesn't readily leach. Potassium (K) and the ammonium form of nitrogen ($NH_4^+$) are positively charged and tend to move slowly due to their attraction to negatively charged soil particles. The nitrate form of nitrogen ($NO_3^-$) is negatively charged and is not attracted to the negatively charged soil particles, so it moves readily through the soil with water. The ammonium form of nitrogen is readily converted to the nitrate form of nitrogen by soil microorganisms under moist, warm soil conditions. Leaching of nitrate nitrogen is our greatest concern.

Precipitation over much of the Snake River Plain is usually not sufficient to move a year's supply of nitrogen below the root zone in medium- or fine-textured soils. In some areas precipitation is received at times of the year when it won't contribute to leaching. On non-irrigated land, nitrogen leaching is likely to be a problem only on coarse-textured soils or in areas of southeastern Idaho at relatively high elevations. Under irrigation, leaching can be serious, depending on soil texture and amount and method of water application. Nitrogen leaching can be minimized by using the best form of nitrogen for the situation, proper application rates and times, and efficient irrigation management.

## 1.07

Q. How can I minimize nitrogen leaching on irrigated land?

A. You should do several things if leaching is a problem. Use ammonium forms of nitrogen, which are subject to leaching only after conversion to nitrate form. Schedule irrigations to maximize water use efficiency. Light and more frequent irrigations are best for minimizing nitrogen leaching losses. In severe cases nitrogen applications should be split into several increments. This is especially true for sandy soils. Split applications will work best on long-season crops such as corn, potatoes, pasture and forages.

## 1.08

Q. When is the best time to fertilize non-irrigated small grains?

A. Time of phosphorus and potassium application makes little difference as long as it is placed in the root zone near seeding. Spring nitrogen applications have lower risk of leaching, denitrification and loss in runoff. You are also likely to know more about soil water conditions in the spring, allowing a more accurate prediction of crop nitrogen needs. The major advantage of fall application is spreading out the farm workload. Though some precautions are necessary, fall application is perfectly acceptable. Fall fertilizer prices may also be less than spring prices.

Volatilization losses of surface-applied nitrogen will be reduced if the soil surface temperature is below 45° to 50°F and fertilizer is incorporated into the soil. Fertilizer can be applied to snow-covered soil as long as the potential for runoff is not significant. Phosphorus and potassium are the fertilizers best-suited for this method. Nitrogen is also suited, although some volatilization losses may occur if the soil is frozen. If the surface soil is not frozen below the snow, little fertilizer will be lost because of runoff.

## 1.09

Q. How should I fertilize a nurse crop when establishing a legume or grass forage crop?

A. Research has consistently shown that nurse crops such as small grains should not be used when establishing forages. Vigor and productivity of the forage is depressed by the nurse crop and the effects last several years.

If the reason for using a nurse crop is soil erosion control, the best solution may be to establish a permanent grass cover, using a grass-legume mix or interseeding. If the reason for the nurse crop is economic (i.e., getting a crop during the year of establishment of the forage crop), then the trade off with reduced long term productivity of the forage must be considered.

Fertilizer application rates should be based on the needs of the target forage crop, **not the nurse crop.**

## 1.10

Q. Can I apply herbicides with my fertilizer?

A. Yes. Herbicides can be added to fertilizer materials, either by impregnating dry materials or by incorporating them with fluids. **Be sure to follow directions on the herbicide label.** Use caution because some combinations are incompatible and can be ineffective or unmanageable. Rely on your fertilizer dealer to do the impregnating. It must be done with precision and shortly before application. Dealers should also be able to check compatibility for you, especially on each batch of liquid fertilizers for soil application.

It is not advisable to blend granular herbicides with dry fertilizer because of differences in particle sizes and difficulty in achieving uniform application. These differences in particle size often cause separation in the applicator box.

## 1.11

Q. Are fertilizers toxic to plants and animals?

A. All fertilizers, whether synthetic or organic, have potential to be harmful if misused. Improper application, direct contact with seed and excessive rates of any nutrient will lead to problems. Regardless of source, use necessary nutrients in correct amounts and apply them properly.

Some fertilizers can be harmful to animals if ingested. Avoid animal access to exposed fertilizer, particularly open sacks or piles. Livestock are attracted to fertilizer as a salt source. Ingestion of as little as a cupful of ammonium nitrate can be lethal.

## 1.12

Q. Are organic nutrient sources more available to the plant than synthetic fertilizers?

A. No. Plants take up nutrients primarily in mineral (inorganic) forms. For example, nitrogen is taken up predominantly as nitrate and to a lesser degree as ammonium. The initial product of organic nitrogen decomposition is ammonium. This ammonium, like synthetic fertilizer ammonium, is converted to nitrate and taken up by the plant. Organic nitrogen sources are more slowly available because of the length of time required for conversion to a usable form. The same is true for most other nutrients, when comparing organic and synthetic forms of fertilizers.

## 1.13

Q. Are there any problems with using manure as a fertilizer?

A. Manure, like other fertilizers, must be applied in appropriate quantities. Proper application rates depend on the type and quality of manure, the soil and crops to be grown. Manures vary widely in the amount of bedding materials (i.e., straw, sawdust, etc.) included. Many manures have a high salt content. Analysis of the manure and soil testing can help prevent problems. Excessive manure can lead to a buildup of nitrate in the soil. Nitrate may not hurt crop production, but it may delay maturity. High soil nitrates may pollute groundwater, cause lodging of small grains, and result in high nitrate contents in forages or leafy vegetables that can be toxic to livestock. Another potential problem is the introduction and spread of weed seeds that can result from manure applications.

Costs of handling and spreading manure are often high compared to commercial fertilizer on a "pounds of nutrient" basis. However, the benefits of organic materials on physical properties of the soil may be substantial.

## 1.14

Q. Is it safe and satisfactory to blend all granular fertilizers?

A. No. There are two reasons why some granular fertilizers should not be blended:

1. **Absorption of water** — While many fertilizers may store well alone, when mixed together they rapidly absorb atmospheric water. In just a few hours, the solid blend may turn to a slurry. Even 1 percent of either product mixed with the other will cause a problem. For example, you should not mix ammonium nitrate (34-0-0) and urea (46-0-0). Some blends of nitrogen and phosphorus fertilizer contain either urea or ammonium nitrate, which may cause problems if blended.
2. **Explosion hazard** — Some mixtures create explosive compounds. Ammonium nitrate is a strong oxidant. When mixed with elemental sulfur (S) or petroleum fuels, ammonium nitrate becomes a sensitive explosive. Open flames, a spark or heat can trigger an explosion. Do not mix ammonium nitrate with elemental sulfur or petroleum products.

## 1.15

Q. To what extent do fertilizers acidify soil, and how can the problem be corrected?

A. All ammonium and sulfur fertilizers may acidify the soil. One of the most acidifying fertilizers is ammonium sulfate (21-0-0-24). A 10-pound application of this fertilizer would require 11 pounds of ground limestone to neutralize the acidity produced. By comparison, a 10-pound application of urea, ammonium nitrate or anhydrous ammonia would require 8, 6 and 15 pounds of ground limestone, respectively, to neutralize the acidity produced.

Nitrogen is an essential plant nutrient that usually must be applied to maintain crop yields. Soils are able to buffer the acidity caused by the application of nitrogen fertilizer. Many western soils contain free lime, which neutralizes acidity. Soils that are already neutral or acidic will eventually require limestone. The need for limestone can be easily monitored by soil testing, which includes checking the soil reaction (pH) and lime requirement.

See University of Idaho Current Information Series 787, "Liming Materials."

## 1.16

Q. Should gypsum be applied to cultivated soils?

A. Roughly 20 percent of western soils are sodium-affected from native sodium contents or by water-borne sodium salts. The pH is usually high (pH 8.3 and above), so calcium in the lime is not soluble. Where suitable drainage is possible, gypsum applications can be used to partially acidify these soils, while displacing the sodium with calcium for both plant nutrition and soil conditioning. Gypsum is a fairly soluble salt so a soil examination and several laboratory tests are required before its use is recommended. Gypsum does not correct soil acidity. Gypsum is a good source of sulfur when sulfur is needed.

## 1.17

Q. What is an "acid-based" fertilizer and how does it differ from other forms of fertilizer?

A. Acid-based fertilizers are a group of liquid and dry products, manufactured from sulfuric and phosphoric acid and nitrogen (usually urea). The manufacturing process results in a fertilizer material with lower pH (more acid) than other fertilizer materials. The pH is usually between 1 and 3. This is why the fertilizer is called an "acid-based" fertilizer. The low pH and the type of nitrogen reaction product, called an adduct, may improve short term availability of nutrients to plants but actually decrease long term availability of P. Acid-based fertilizers are used primarily for banding, although they are also equally effective when broadcast and incorporated.

Often the urea-phosphate fertilizer combination (UP) is ammoniated to produce a granular or fluid urea-ammonia-polyphosphate. These fertilizers do not differ much from other nitrogen-phosphorus fertilizers except in regard to their pH or acidity.

## 1.18

Q. What is an economically justifiable fertilizer rate? How do I figure out how much I can afford to spend on nitrogen?

A. Any fertilizer application that increases economic return more than it costs to buy, store and apply is economically justified. This usually means operating slightly below the "maximum yield." Maximum yield may not be the most profitable. The amount of money spent on fertilizer should also be based on estimated or expected "yield goal." As long as yield goals are realistic, and the goal is near "maximum economic yield," apply fertilizer at a rate that, when combined with residual soil nitrogen, will allow realization of that goal. Operating at or very near the "top" of the yield response curve usually means that money spent on nitrogen will normally return more than the cost of nitrogen. Adequate phosphorus and potassium must also be available to obtain the yield goal and assure maximum efficiency of applied nitrogen. When growers have sufficient money available to purchase all the fertilizer needed to maximize net returns above fertilizer cost, the following rule should be applied: Put on fertilizer until the:

$$\begin{bmatrix}\text{Additional}\\ \text{expected}\\ \text{bushels/acre}\end{bmatrix} \times \begin{bmatrix}\text{Expected}\\ \text{price/}\\ \text{bushel}\end{bmatrix} = \begin{bmatrix}\text{Additional}\\ \text{pounds}\\ \text{fertilizer/acre}\end{bmatrix} \times \begin{bmatrix}\text{Price/pound}\\ \text{of}\\ \text{fertilizer}\end{bmatrix}$$

This is the rate at which net returns above fertilizer costs per acre will be maximized, not the rate that will provide the maximum yield.

# Section 2. Soil Testing

## 2.01

Q. Are the nutrient forms reported in soil test results the same as those reported in fertilizer products?

A. Yes and No. Most soil testing laboratories report nutrients in the soil on the elemental basis for nitrogen (N), phosphorus (P), potassium (K), sulfur (S) and other elements. All nutrients in fertilizer products are reported on the elemental basis except phosphorus and potassium. They are reported as the oxides of phosphorus ($P_2O_5$) and potassium ($K_2O$). For example, the fertilizer 10-30-10-(5) contains 10 percent N, 30 percent $P_2O_5$, 10 percent $K_2O$ and 5 percent S by weight. (Conversion factors: $P_2O_5 \times .44$ = percent P, $K_2O \times .83$ = percent K)

All soil test recommendations for fertilizer are reported on the fertilizer nutrient basis, so nutrient requirements are given as pounds per acre of N, $P_2O_5$, $K_2O$ and S. In local usage, the term "unit" is synonymous with pound per acre.

## 2.02

Q. I split one of my soil samples into three equal parts and sent the subsamples to three different soil testing labs. The results of the analyses from the three labs were different. Why?

A. A small amount of variability in analytical results from different labs is unavoidable, but the differences should be less than 10 percent between labs. Significant differences in results are usually caused by one of the following:

1. **Improper splitting of samples** — Soil should be dried, crushed, sieved and thoroughly mixed, and then carefully divided into samples for testing.
2. **Different test procedures between labs** — Several procedures are possible for most soil tests. Each procedure can give a different test result. A lab's choice of testing procedure depends on its past experience, geographic area and current research findings.
3. **Poor analysis** — Unfortunately, mistakes do occasionally occur at a lab, and lack of attention to quality control can lead to variable results.

The best approach is to find a reputable and reliable lab and stick with it. The lab should be able to explain why they use certain procedures. Request that the same procedures be used for your samples each year.

## 2.03

Q. Do all soil testing laboratories use the same units for reporting nutrition levels in soils?

A. No. Generally, one of three different types of units is used for reporting amounts of nutrients in soils. The three types are parts per million (ppm), pounds per acre (lb/acre) and milliequivalents per 100 grams of soil (meq/100g). These differences can cause confusion when you compare soil test results from two laboratories. The soil test results can be converted to a common unit as follows:

ppm = parts nutrient/one million parts soil

lb/acre = pounds nutrient/acre slice

a 6-inch acre slice = approximately 2 million pounds

a 0- to 6-inch sample depth = $2 \times$ ppm = lb/acre

a 0- to 12-inch sample depth = $4 \times$ ppm = lb/acre

therefore,

$$\text{lb/acre} = \frac{\text{sample depth in inches}}{3} \times \text{ppm}$$

Calcium (Ca), magnesium (Mg) and sodium (Na) are reported either in parts per million (ppm) or milliequivalents per 100 grams of soil. Milliequivalent units are customarily used when preparing reclamation recommendations for sodic soils. Use the following to convert ppm to meq/100g:

For calcium, ppm/200 = meq/100g
For magnesium, ppm/120 = meq/100g
For sodium, ppm/230 = meq/100g

## 2.04

Q. How important is soil sampling, and what is the correct procedure to use?

A. Soil sampling is the most important step in a soil fertility program. The procedure is not complicated if you have proper tools and instructions. First you must recognize that soils are highly variable. To account for this variability, at least 20 subsamples must be taken from different parts in a uniform field or growing area. A core sampling tool will ensure that the same amount and depth of soil are taken at each subsampling site. Many fertilizer dealers will sample soil for you, at no added cost.

Place all subsamples in a clean, plastic pail, and when the area has been thoroughly sampled, completely mix the soil in the pail. Pulverize all of the lumps and mix the soil carefully to produce a uniform composite sample. Submit two cups of the mixture for testing. The sample should be air-dried if possible. Samples should be loosely packed in a wax or plastic lined brown paper bag.

Use this same procedure for taking samples from large and small fields or from problem growth areas. Failure to follow these simple steps will result in an inadequate or contaminated sample, which will give misleading and perhaps costly recommendations.

## 2.05

Q. How reliable will my fertilizer recommendations be if I don't soil test?

A. Results of a soil test are the most useful and reliable information upon which to base a fertilizer recommendation. Many factors contribute to variability and uncertainty about soil fertility levels. A soil test will provide an accurate assessment of the nutrient levels for which tests are run. Results of a soil test are much like a gas gauge in an automobile, telling you the reserve level. Without a soil test, a recommendation can be made only on the basis of estimates and assumptions. In such a case, the safest assumption is that there are no nutrient reserves in the soil and you need to supply the plant's entire nutrient needs through a fertilizer program.

## 2.06

Q. What is the best time of year to collect soil samples for fertilizer recommendations?

A. Nitrogen is the most variable soil constituent that is measured by soil testing. The best test for nitrogen is made close to time of plant need. Soil nitrate nitrogen values from samples taken in the fall for spring fertilizer applications may require adjustment for mineralization or for leaching losses that occur during the winter. Recent research in the Northern Plains has shown that 15 to 30 pounds of nitrogen per acre can be mineralized between fall and spring. The actual quantity will depend on temperature and soil organic matter levels. Other soil test levels are less variable with time, so timing of sampling is less critical. Take soil samples at any time of year when attempting to diagnose crop growth problems.

## 2.07

Q. Is special consideration required when taking and handling soil samples for nitrate-nitrogen analysis?

A. Yes. Since nitrate-nitrogen is mobile, it is necessary to collect soil samples from the entire effective rooting depth of the crop to be grown. This will depend on both the rooting characteristics of the crop and soil depth. In addition to the normal procedure of taking a representative sample, composed of at least 20 individual cores, nitrate samples must be air-dried or frozen before transport to the laboratory. When a moist sample warms up to room temperature and is well aerated, decomposition of organic matter is speeded up, releasing nitrate. The additional nitrate is included in the test value, resulting in an erroneously high test result and a nitrogen fertilizer recommendation that is too low. Drying decreases microbial activity and helps ensure representative test results.

## 2.08

Q. Under what conditions should I take deep soil samples?

A. Deep samples, such as 12- to 24-inch and 24- to 36-inch increments, are sometimes recommended for cultivated crops. Many irrigated and dryland cultivated crops will extend roots to 5 feet if soil is that deep. Although surface soil is usually the most fertile layer, chemical and physical conditions in the subsoil can significantly affect crop growth. Measurement of soluble nutrients, such as nitrate-nitrogen and sulfur, is improved by deep sampling. Deep samples also provide valuable information about salt accumulation, pH changes and texture differences within the root zone. Deep samples should be taken from irrigated fields where deep-rooted crops are to be grown and especially from fields where long-season crops are grown and late-season uptake of nitrogen is a concern. Potatoes, sugarbeets and malting barley are especially sensitive to high nitrogen levels late in the season.

## 2.09

Q. Why don't soil testing labs use the deep soil sample for nitrate-nitrogen for legumes and perennial grasses?

A. Bacteria (*Rhizobia*) in nodules on roots of legumes fix atmospheric nitrogen for their own use and the use of the legume plant. A portion of this N may be added to the soil. Therefore, nitrogen fertilizer applications aren't required, and there is little need to soil test for nitrogen.

Very little nitrate-nitrogen is found under sod-forming crops such as perennial grasses. Nitrogen is present in other forms, mostly as humus and root tissue.

# Section 3. Nitrogen Management

### 3.01

Q. What is the process of nitrogen fertilizer transformation from the time it is applied until it becomes available to the plant? What are the various forms of nitrogen in this conversion process?

A. The simplified diagram below shows some of the major reactions of nitrogen in the soil and the chemical forms involved. These reactions are referred to as the "nitrogen cycle."

Plants use primarily nitrate ($NO_3^-$) and to a lesser extent ammonium ($NH_4^+$) from the soil. Plants do not discriminate between sources of these nitrogen forms. The two sources are fertilizer and organic matter. Organic materials, such as manure and crop residues, are decomposed by soil organisms. This biological conversion process causes ammonium to be formed. Ammonium, from either fertilizer or organic matter, is converted by bacteria to nitrate in a process called nitrification. Nitrate is an intermediate end product, which accumulates in aerated soil. The conversion of organic nitrogen into a plant-usable form is called mineralization.

Nitrate and ammonium are the forms of nitrogen usually added by fertilization. Other important nitrogen processes include:

1. **Denitrification** — The conversion of nitrate to a gas. The gas is usually released to the atmosphere and is no longer available to the plant.
2. **Leaching** — This is a physical process or the movement of nitrogen (usually nitrate) by downward movement of soil water.

### 3.02

Q. How late in the spring can I delay nitrogen application to small grains?

A. The best rule is to apply nitrogen in the spring as early as possible. If you can't make a preplant application, nitrogen will still be effective when applied before the 4- to 5-leaf growth stage for small grains. Rainfall or irrigation is necessary to move post-plant applications of nitrogen into the root zone. Nitrogen applied near the boot stage may increase protein content of small grains. Nitrogen application after the 4- to 5-leaf stage should be avoided when low protein is desired, as is the case with malting barley.

### 3.03

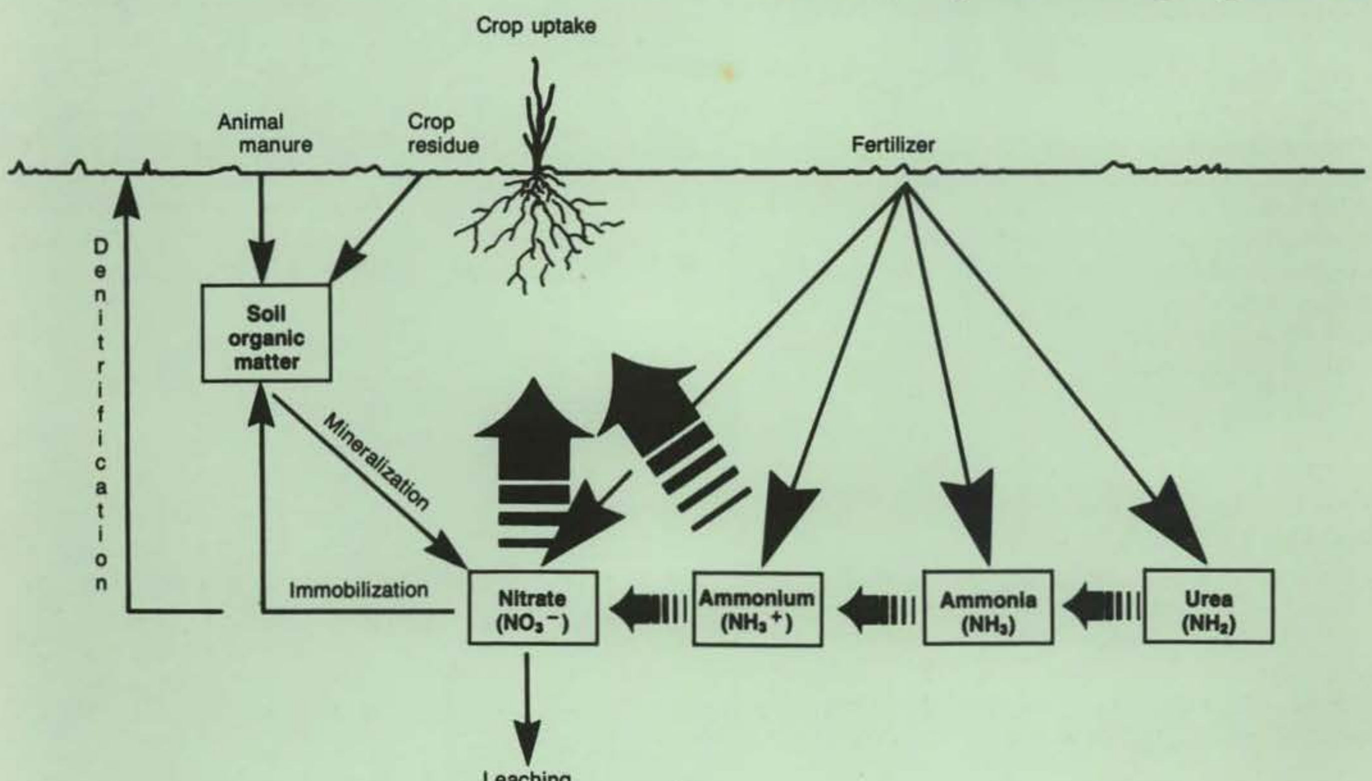
Q. Why is it so important to apply nitrogen in the spring as early as possible?

A. Cereal grains take up the most nutrients early in the growth cycle (i.e., during vegetative stages). This helps establish the number of tillers and heads per acre. Nitrogen must be available when it is needed most. Inadequacies that occur during the vegetative stage can't be made up later. Early nitrogen application is not as critical for long-season crops such as corn, potatoes, pasture or hay.

### 3.04

Q. Will late or delayed application of nitrogen increase grain protein?

A. Sometimes. Several researchers have found protein increases in small grains when nitrogen applications are



made up to flowering. The actual economic value benefit will depend on the premium offered for protein, for example, of hard red wheat. Twenty to 30 pounds of nitrogen applied through the irrigation system between heading and flowering provides best results under southern Idaho conditions. Irrigation or precipitation will be needed to move the nitrogen into the root zone. Value of the increased protein must be weighed against added cost and inconvenience of applying the nitrogen.

There is no substitute for adequate nitrogen fertilizer applied early in the crop growth cycle. Supplemental application of nitrogen to increase protein should be viewed as part of the normal recommended rate. See University of Idaho Current Information Series 828 "Irrigated Spring Wheat, Southern Idaho."

## 3.05

Q. Should I apply nitrogen to small grains through my irrigation system?

A. This practice is referred to as fertigation or nitrigation. Fertigation is especially suited on coarse-textured soils, where leaching is a problem. Research has shown that at least 75 percent of the required nitrogen should be applied at seeding or shortly thereafter for spring grains, and the same amount should be applied in the fall or early spring for winter wheat. Delaying application of the majority of required nitrogen will considerably reduce yields. Use fertigation to apply 20 to 30 pounds N (average) between heading and flowering.

## 3.06

Q. What is foliar feeding and will it improve small grain yields?

A. Foliar feeding is spraying a nutrient solution on the foliage. Nutrients are then absorbed into the plant through the leaves. Quantities of the primary nutrients (nitrogen, phosphorus and potassium) that can be applied and absorbed are too small and the application is usually too late to be of much value. Foliar feeding can be effective for correcting confirmed micronutrient deficiencies. Fortunately, this has not been much of a problem with small grains. Foliar feeding is not the same as fertigation.

## 3.07

Q. Will fertigation or foliar feeding burn the vegetation? How much will this reduce yield?

A. Foliar application of large amounts of nutrients or concentrated solutions may damage leaf tissue, causing "burning." Effect on yield depends upon the extent of damage and growth stage of the plants. Plants recover quickly from slight leaf damage early in the growth cycle. However, damage to the small grain flag leaf may reduce grain yield and quality. Foliar application of nitrogen solutions (not fertigation) containing 20 pounds nitrogen per acre or more may damage the leaves.

Proper fertigation will not cause burning. The fertilizer should be applied early in the irrigation if possible, so nutrients will be washed off the foliage. Again, note that fertigation is not foliar feeding.

## 3.08

Q. How much nitrogen can I place with cereal grain seed when planting?

A. High concentrations of nitrogen and potassium, placed in direct contact with the seed, reduce germination and emergence. Low soil moisture aggravates the problem. Caution is necessary under non-irrigated conditions. The following guidelines have been developed for non-irrigated fields, to reduce the risk of stand damage and subsequent yield reduction.

1. Don't band more than 10 pounds/acre urea with the seed if you are using a narrow opener, which places seed and fertilizer together. If you are using wide sweeps or shovels (6 to 12 inches) with pneumatic seeders and seed and fertilizer are widely dispersed, rates as high as 40 pounds urea/acre can be applied with the seed.
2. For non-calcareous soils:

   Monoammonium phosphate (11-52-0) — use no more than 20 pounds N/acre.

   Diammonium phosphate (18-46-0) — use no more than 15 pounds N/acre; (20 pounds if soil is very moist).
3. Calcareous soils (fizz with hydrochloric acid) — reduce the non-calcareous soil rates by 5 pounds/acre.
4. Reduce rates for dry soil conditions or row spacings wider than 12 inches.
5. Row spacings less than 12 inches permit higher rates.
6. If potassium is placed with the seed, the above rates include nitrogen (pounds N/acre) plus potassium (pounds $K_2O$/acre).

## 3.09

Q. Do I need to add extra nitrogen if I incorporate crop residue such as straw?

A. Yes. Add 15 to 20 pounds of extra nitrogen per ton of residue incorporated per acre up to 45 to 50 pounds nitrogen/acre. Extra nitrogen may be necessary if residue is incorporated close to seeding time, or if seeding is done into standing residue. This compensates for short term tie-up of nitrogen by soil microorganisms decomposing the residue. Nitrogen is released after decomposition but this may be too late for the current crop.

## 3.10

Q. Is there an advantage to providing starter or "pop-up" fertilizer at seeding time?

A. Research has shown that yields usually can be increased by placing some nitrogen and phosphorus with or near the seed of small grains and row crops. Starter fertilizer improves seedling vigor and gives plants an early start. With the advent of deep banding (dual banding of nitrogen and phosphorus 2 to 4 inches below the seed), need for a starter fertilizer with the seed has been questioned. Generally, deep banding of nitrogen and phosphorus will be adequate to meet plant requirements. However, on low phosphorus soils or under cold or wet soil conditions, some starter phosphorus placed with the seed may still be beneficial.

## 3.11

Q. Is there an advantage to applying nitrogen when establishing alfalfa?

A. Rarely. Moderate to high nitrogen levels when establishing alfalfa inhibit nodulation by nitrogen-fixing bacteria and increase weed competition. Both effects will reduce the productivity of an alfalfa stand.

If residual soil nitrogen levels are low, small amounts of nitrogen fertilizer (less than 30 pounds per acre) won't adversely affect stand establishment and will help develop a young, vigorous stand. As residual soil plus fertilizer nitrogen levels increase, nodulation is inhibited and the plants will rely on soil nitrogen.

See University of Idaho Current Information Series 827, "Irrigated Alfalfa in Southern Idaho."

## 3.12

Q. Will alfalfa respond to nitrogen fertilizer?

A. Sometimes. Stands that do not nodulate will respond to nitrogen. Stands that are 5 to 6 years old may also respond to nitrogen applications. The older stands no longer fix enough nitrogen for their own needs. Bacteria will not effectively fix nitrogen within the plant if the available soil nitrogen level is high. It is more likely that grass in older stands is giving the yield response to applied nitrogen with the alfalfa being crowded out. The best management practice is to plow out the stand and establish a new one.

Alfalfa is a heavy user of soil phosphorus, potassium and sulfur. Supplying adequate amounts of these nutrients will improve yield and longevity of the stand. Recent research and new fertilizer techniques have shown that established stands of alfalfa will respond to fertilizer that is "knifed in" several years after the stand has been established. This physical disruption also seems to revitalize the stand in many cases.

## 3.13

Q. What problems am I likely to encounter if I use urea?

A. Urea is a very good source of nitrogen. However, some precautions should be observed for most effective use. When urea is placed with the seed, risk of seedling damage is greater than with other granular sources of nitrogen. Seedlings are damaged by the ammonia produced as urea is converted to ammonium in the soil. Although surviving plants may compensate for stand damage, there is still a good possibility of yield loss when urea is applied with the seed at high rates.

Nitrogen may also vaporize (volatilize) from surface-applied urea. Losses are greatest with high temperatures, high soil pH, free $CaCO_3$, high organic matter and intermediate humidity. The best practice is to incorporate urea into the soil by banding, tillage or irrigation. Otherwise, urea should be applied when the soil surface temperature is below 50°F or the air temperature is below 40°F.

Never mix urea with a nitrate-containing fertilizer since they are incompatible and will form a slurry that cannot be spread (see question 3.08).

## 3.14

Q. Will excess nitrogen really reduce sugarbeet quality?

A. Yes. Excessive nitrogen will promote beet top growth thereby reducing the amount of energy stored in the beet root as sucrose. Nitrogen levels must be adequate during the bulk of the growing season. Sucrose production is greatest when the beet plants become water- and nitrogen-deficient toward the end of the growing season. This deficiency causes the plant to reduce overall energy use because the plant does not have the materials to grow. The result is an accumulation of energy stored in the form of sucrose in the root. Excessive nitrogen causes the plant to use energy for growing unharvested tops.

Soil testing is the best way to account for residual soil nitrogen which constitutes the basis for an accurate fertilizer recommendation.

See University of Idaho Current Information Series 271, "Sugarbeets," for specific sugarbeet fertilizer recommendations.

## 3.15

Q. When should I apply nitrogen to sugarbeets?

A. Nitrogen can be applied in the fall on loam, silt loam and "heavier" soils (clayey soils). Apply the ammonium or urea forms of N when soil temperatures are below 45°F to minimize N loss from winter leaching. Spring applications, either preplant-incorporated or side dressed before July 1, may provide increased fertilizer efficiency. Try to meet N needs before July 1 as N applied after July 1 may reduce sucrose accumulation in the root.

## 3.16

Q. Will excess nitrogen affect potato yield and quality?

A. Yes. Excessive N will cause delayed tuber set, poor netting, unnecessary vine growth, reduced yields and reduced solids in indeterminate varieties such as Russet Burbank. Nitrogen applications should be carefully scheduled to meet, not exceed, the crop requirement for a particular stage of growth.

See University of Idaho Current Information Series 637, "Scheduling Nitrogen Applications for Russet Burbank Potatoes."

## 3.17

Q. Should I include nitrogen in my dry bean fertility program?

A. Beans are capable of "fixing" sufficient N and therefore under most conditions they do not require additional fertilizer N. However, when beans follow small grains or corn, additional N should be applied to aid in straw decomposition and provide adequate available N for early growth (see question 3.09). Refer to University of Idaho Current Information Series 378, "Beans."

## 3.18

Q. How will nitrogen affect irrigated malting barley yield and quality?

A. Grain protein and yield increase with increasing nitrogen supply up to about 120 pounds fertilizer plus residual soil nitrogen. At this 120 pound nitrogen level, protein continues to increase but yield levels off. For malting barley, excessive protein is not desirable, so it is essential to reach top yield level without abnormally high protein. Kernel plumpness decreases with increasing nitrogen levels. Excess nitrogen reduces kernel plumpness and increases grain protein, both undesirable characteristics for malting barley. See University of Idaho Current Information Series 810, "Malting Barley."

# Section 4. Anhydrous Ammonia

Anhydrous ammonia use need not be dangerous. Maintain the equipment, follow safe procedures during handling, be sure safety equipment is used and keep a supply of fresh water within arms reach. Do not become careless at any time.

## 4.01

Q. What is anhydrous ammonia?

A. Anhydrous ammonia is a simple form of nitrogen fertilizer. It is made up of one part nitrogen and three parts hydrogen ($NH_3$). Anhydrous ammonia is a gas at atmospheric temperatures and pressures. It contains 82 percent nitrogen, making it one of the highest analysis and more economical fertilizers on the market.

## 4.02

Q. How does anhydrous ammonia compare to other dry and liquid fertilizers as a nitrogen source?

A. All commonly used nitrogen sources are equally effective, if they are properly applied. If they are applied correctly, the plant can't tell the difference. Major differences between nitrogen sources are the cost of each material, the efficiency of handling, application and placement, and the length of time it takes for each form to convert to the nitrate form.

Cost of anhydrous ammonia is typically lower per pound of nitrogen than other materials. It is the starting material used for manufacture of most other dry and liquid nitrogen fertilizer. It follows that other materials have higher manufacturing costs. Higher analysis of anhydrous ammonia (82 percent N) also serves to reduce transportation costs. However, special equipment is required to place the ammonia into soil. This equipment includes a pressure regulator, manifold, distribution tubes, shanks and a pressure tank. It is necessary to calculate how much nitrogen must be applied at a given price differential to pay for the added equipment.

Fertilizer materials must be evaluated in terms of how well they fit farming operations. Savings may be realized by combining ammonia application with a normal tillage operation.

## 4.03

Q. Is anhydrous ammonia dangerous?

A. Yes! Two features of anhydrous ammonia require that it be handled carefully:

1. Anhydrous ammonia is stored and handled as a pressurized liquid. Normal precautions used with pressure equipment are necessary. Escaping ammonia gas freezes whatever it contacts.
2. Anhydrous ammonia has an extreme affinity for water. It can instantaneously pull water out of human tissue, particularly damaging the eyes, nose and throat. First aid consists of applying clean water — and a lot of it — immediately. **Continue flushing with water for 15 minutes.**

## 4.04

Q. Are there any advantages that encourage the use of anhydrous ammonia over other available nitrogen sources?

A. The biggest advantage is cost. Anhydrous ammonia may cost as little as 50 percent of the cost of other nitrogen materials (ammonium nitrate, urea or nitrogen solutions).

## 4.05

Q. How long will anhydrous ammonia last after it is injected into the soil?

A. Anhydrous ammonia reacts with water or other sources of hydrogen associated with organic matter or clay in the soil and is converted to ammonium ions ($NH_4^+$) as soon as it is injected into the soil. Ammonium ions are immobile and will not leach, since they are attracted to negative charges associated with organic matter and clay. The ammonium will remain in the soil until soil temperatures rise above approximately 50°F. The ammonium first converts to nitrite and then to nitrate, which is either used by the plant, leached with downward movement of soil water, lost by gaseous conversion or remains in the soil solution.

The length of time nitrate-nitrogen remains in the soil depends on crop demands, soil temperature, soil texture and the amount of leaching (see question 3.01).

## 4.06

Q. How deep should anhydrous ammonia be placed in the soil to avoid nitrogen losses?

A. Placement depth depends on soil water content, soil texture, application rate and soil physical condition. If these factors are optimum, depth can be 3 to 4 inches. The farther these conditions are from optimum, the deeper the anhydrous must be placed. Imagine the zone of ammonia placement as a continuous cylinder running through the soil. Diameter of the cylinder is determined by how far the ammonia moves before it is absorbed into soil water. A soil at field capacity will absorb ammonia quickly and the cylinder will have a small diameter. As conditions become drier, the cylinder diameter expands and ammonia must be placed deeper in the soil to prevent the cylinder from reaching the soil surface, causing loss of ammonia into the atmosphere. Coarser soil texture and higher application rates also cause a larger cylinder and necessitate deeper placement. Depths of 6 to 8 inches may be necessary for some conditions.

## 4.07

Q. How will I know if I'm getting the anhydrous ammonia deep enough?

A. You can assume the anhydrous ammonia is being placed deep enough in the soil if there is no noticeable ammonia odor and if you do not see wisps of white ammonia gas behind the applicator. It is easy to tell when ammonia is being lost because of the sharp, pungent odor. The reaction with soil is almost immediate. If you can't detect anhydrous ammonia loss within a few minutes of application, it will not be lost as vapors.

## 4.08

Q. Does anhydrous ammonia make the ground hard?

A. There are no data to indicate that anhydrous ammonia adversely affects soil physical properties, such as density and structure. The claim of ammonia hardening the ground is best categorized as unsubstantiated rumor.

Several circumstances could give rise to such a rumor. Continuous cultivation and long term cropping have resulted in a decline in soil organic matter. Organic matter is an important component in keeping soil mellow and promoting good structure. Cultivation is also disruptive to soil structure and causes compaction in some fields. At the same time, crop removal and higher yields have increased nitrogen fertilizer requirements. Anhydrous ammonia accounts for a substantial portion of nitrogen fertilizer sales. Since decreasing soil workability has occurred at the same time as anhydrous ammonia use has increased, one could erroneously assume that anhydrous use is related to poor soil physical properties.

Reduced organic matter levels are also related to summer fallowing in small grain-producing areas of southeastern Idaho. Fertilizer use has also increased. Nitrogen fertilizer use will become more and more necessary as organic matter levels decrease. Fertilization will not cause organic matter to decrease; decreases in organic matter are caused by tillage, which speeds up decomposition. Additional nitrogen fertilizer in association with recropping has led to increased levels of soil organic matter.

## 4.09

Q. Should soil temperature be a consideration when determining time of application of anhydrous ammonia?

A. Cold soils can retain ammonia very well. This is important to remember in considering fall applications of anhydrous ammonia. Anhydrous applications should be delayed in the fall until the surface soil temperature is about 50°F or below, if nitrate-nitrogen leaching or denitrification is a concern.

## 4.10

Q. Is soil water content a consideration in anhydrous ammonia application?

A. Spring applications can be made any time field conditions allow. Excessively wet soils can cause sealing problems and ammonia gas losses behind the injector shanks. The same is true for soils that are too dry; without adequate soil moisture, the anhydrous will not be held in the soil and will be lost to the atmosphere.

## 4.11

Q. What injection spacing is best to obtain uniform application of anhydrous ammonia?

A. Injection spacing will depend somewhat on the time of year the application is made. For preplant spring application on small grains, 9- to 12-inch spacings are desirable to prevent nitrogen streaking. Streaking occurs from injection of high rates of anhydrous application with shanks widely spaced. Green "streaks" appear in the field because nitrogen has not been equally distributed through the soil. Spacings of 15 to 18 inches can be used successfully, if a tillage operation is done 10 days to 2 weeks after anhydrous application and before planting. This secondary tillage will redistribute the nitrogen. In a fall application, 18- to 20-inch spacings will be adequate where some secondary tillage is performed in the fall or before seeding in spring.

## 4.12

Q. Is speed a consideration when applying anhydrous ammonia?

A. The faster the equipment travels, the greater tendency injector knives or shanks have to bounce and lift out of the soil. As a result, placement may be shallower than desired, resulting in ammonia losses. The rate of chemical applied will also be affected. Most application equipment is precalibrated for a particular speed.

## 4.13

Q. Can anhydrous ammonia be used on existing stands of small grains, grasses (pasture) or alfalfa?

A. If anhydrous ammonia is applied to existing stands, it is best to use the true anhydrous applicator knife to keep mechanical damage to a minimum. In small grains, a few plants will be injured or destroyed, but tillering will compensate for most loss of plants. When making applications on grass pastures, be attentive to ensure a good seal on the slot created by the knife.

Vigorous, healthy alfalfa stands should not require addition of nitrogen fertilizer and often will not respond to it (see questions 3.12 and 3.13).

## 4.14

Q. Can row crops be side-dressed with anhydrous ammonia?

A. Row crops can be side-dressed with anhydrous ammonia if additional nitrogen is needed after the crop is planted. However, the knife should be kept near the center between rows to minimize root damage. Side-dressing with anhydrous ammonia is an accepted practice for corn, potatoes and sugarbeets.

## 4.15

Q. Dealers often talk about N-Serve and Cold-flo when referring to the use of anhydrous ammonia. To what do these two terms refer and how do they affect my use of anhydrous ammonia?

A. N-Serve is a chemical that slows down the conversion of ammonia or ammonium-nitrogen to nitrate-nitrogen, the leachable form of nitrogen. N-Serve is mixed with the anhydrous ammonia. The situation created by N-Serve is somewhat like the conditions created by soil temperatures of about 50ºF or below. N-Serve has possibilities under special conditions for delaying the conversion of nitrogen into the leachable nitrate-nitrogen form on soils in which leaching or denitrification losses of nitrate are significant.

Cold-flo makes use of the refrigeration characteristic of anhydrous ammonia, allowing it to be applied primarily as a liquid instead of a gas. An expansion chamber must be added to the application equipment. The refrigeration action of anhydrous ammonia in the expansion tank transforms approximately 85 percent of the ammonia into a cold liquid. The remaining 15 percent is a very low pressure gas. The Cold-flo ammonia is released under the soil as a non-pressure liquid or as a very low pressure vapor. This allows anhydrous ammonia less chance to escape. If you are having problems with ammonia loss, equipment expense of Cold-flo may be offset by reduced loss.

## 4.16

Q. Does anhydrous ammonia kill soil organisms such as bacteria and earthworms?

A. High concentrations of ammonia are toxic to organisms, including bacteria, worms and seedlings. Bacteria and other soil organisms are reduced in the zone where anhydrous ammonia is placed. However, populations usually recover rapidly and usually reach higher numbers than before application. This subsequent increase is due to nitrogen that has been added to the soil system. Although total numbers of microorganisms may not be affected over the long run, ammonia could shift the balance toward or away from some beneficial species.

## 4.17

Q. Does anhydrous ammonia acidify the soil?

A. The initial reaction of anhydrous ammonia with water in the soil results in an increase in soil pH in the immediate zone or band where the fertilizer is applied. However, the pH will drop back to previous levels as nitrification occurs. This process may take as long as 3 to 4 months. Long-time use of ammonia can cause eventual acidification of neutral or slightly acid soils (see question 1.15).

## 4.18

Q. Since ammonia is toxic to seedlings, how long must I wait between the time I apply anhydrous ammonia and seeding?

A. A minimum waiting period of 2 days is generally recommended. However, recent conservation tillage studies have shown that seeding can be done at the same time anhydrous is applied, as long as the seed is physically separated from the fertilizer by 2 to 3 inches. The time required for anhydrous ammonia to dissipate to safe levels will vary widely, depending on rate of application, depth of application in relation to seeding depth, soil moisture and soil texture. Potential damage will be reduced and the waiting period will be shorter with good soil water.

If you are in doubt about seeding too soon or at the same time as fertilizing, some precautions may help minimize damage. If anhydrous is applied separately, apply the anhydrous crosswise to the direction you will seed. This avoids having drill openers follow an ammonia application track, damaging one row at a time. Deeper ammonia application will also help you avoid seeding directly into the middle of the zone of placement.

## 4.19

Q. When is the best time to apply anhydrous ammonia?

A. The most economical way to use anhydrous ammonia may be to install the regulator and distribution tubes on your normal chisel plow and combine nitrogen application with a regular tillage operation. Late fall application is excellent, as is early spring application. Fall application of anhydrous ammonia for sugarbeets provides nitrogen for microbial decomposition of stubble or corn stover. It may be possible to combine application with a late summer or fall fallow operation. However, stimulation of weeds and loss of water may be problems on summer fallow. Applying phosphorus fertilizer in the same operation may improve efficiency and reduce the amount of fertilizer handling at seeding time. Anhydrous ammonia has been successfully applied at the same time as seeding in conservation tillage systems, as long as the seed and fertilizer are separated.

# Section 5. Phosphorus

## 5.01

Q. Why is banding phosphorus fertilizer sometimes more effective than broadcasting phosphorus on small grains?

A. In soils testing low in phosphorus, P uptake efficiency may be greater when the phosphorus is banded or placed with the seed than when it is broadcast. As soil test levels increase, the difference in efficiency decreases. Banding reduces contact between soil and fertilizer particles, thereby slowing formation of low-solubility phosphorus compounds, which reduce availability. Spring grains normally take up most (90 percent) of their phosphorus the first 40 days of growth. Placing phosphorus fertilizer in a band near the seed has proven to be beneficial to plant growth and yield because ample phosphorus is available to the young plant during the peak requirement period.

## 5.02

Q. Why do the various phosphorus fertilizers differ in their availability to affect crops?

A. Most manufactured phosphorus fertilizers are soluble in water and therefore initially quite available for plant uptake. For example, ammonium phosphates (18-46-0, 11-52-0) are nearly 100 percent soluble, and triple super phosphate (0-45-0) is about 95 percent soluble when the fertilizer is applied and mixed with the soil. The soil water solubilizes the fertilizer, and the phosphorus is rapidly transformed to less soluble compounds. In acid soils (below pH 7.0), the reaction products are iron and aluminum phosphates. In alkaline soils (pH greater than 7.0), the products are calcium and magnesium phosphates. Phosphorus availability is usually highest in near-neutral soils — those with pH between 6.0 and 7.5.

Phosphorus fertilizers are made from an ore called rock phosphate. Without processing, rock phosphate is only slightly water soluble. Less than 5 percent of the phosphorus from the ore will move into the soil solution during an entire year.

## 5.03

Q. Should I band or broadcast phosphorus before planting potatoes?

A. Probably the best way to satisfy potato phosphorus requirement is to soil test to determine the need for additional phosphorus. Broadcast and incorporate before bedding. See University of Idaho Current Information Series 261, "Potatoes."

## 5.04

Q. If I have to broadcast phosphorus, what happens to the extra fertilizer (i.e., the amount in excess of the banded rate)?

A. The extra fertilizer stays in the soil and becomes part of the reserve pool, although it will be changed to less available forms. This extra phosphorus will be reflected in higher soil tests in future years and lower annual applications will be necessary.

Large applications of phosphorus fertilizer, intended to last several years, have been shown to work, but the economics of such applications must be considered. This approach is often called "banking" phosphorus.

## 5.05

Q. I can't incorporate phosphorus on no-till grain or on existing perennial forages. What should I do?

A. The best approach in both cases is to ensure an optimum soil phosphorus supply, as reflected by the soil test, early in the life of the forage crop.

Large applications of phosphorus should be incorporated before forage is established. Surface application of phosphorus on established forage may take a year or more to show a yield response but will generally be effective on soils that test low in phosphorus.

In the case of no-till grain production, new planting equipment generally allows for enough phosphorus to be banded with the seed at planting or deep banded below and to the side of the seed to meet the crop's entire phosphorus requirement. Some studies have even shown this approach to be the most efficient use of phosphorus (see question 5.01).

## 5.06

Q. How much phosphorus can I place directly with the seed?

A. Traditionally, phosphorus applied to annual crops has been placed near the seed with the drill at seeding time. Few instances of phosphorus damage or injury to small grain seedlings have been reported or noted. The wide furrow created by hoe-type drills and air seeders equipped with wide shovels or sweeps is less likely to cause damage than disk drills and may be less damaging when high rates of fertilizer are used.

# Section 6. Potassium

## 6.01

Q. Should I be using potassium in my fertilizer program?

A. Use of potassium and all fertilizer nutrients should be based on the soil test concentration, expected crop yield and quality response. Be sure the increased yield and improved quality more than pay for the cost of fertilizer. Soil tests and field trials should be used to establish requirements for potassium fertilizer. Compare a strip treated with your normal nitrogen-phosphorus rate to a strip treated with the same amount of nitrogen and phosphorus plus potassium. Where irrigation is used, make allowances for the average potassium content of irrigation waters.

## 6.02

Q. Does the potassium soil test accurately predict when potassium fertilizer should be used?

A. A soil test can identify potassium-deficient soils. On soils with marginal levels of potassium, test strips should be used to establish whether addition of potassium is beneficial. Soil testing, combined with test strips, is reliable in marginal response situations.

Potassium chloride is used on wheat in Washington and Oregon for disease control. Chloride has been shown to help control the root disease "take all." Recent research in Montana has shown similar results.

## 6.03

Q. What rates of potassium are necessary to provide adequate crop nutrition?

A. Apply 30 to 50 pounds of potassium ($K_2O$) per acre, if you are applying test strips to check for a potassium response. In many cases, 25 to 30 pounds per acre are sufficient. Irrigated small grains have responded to as much as 50 to 70 pounds per acre. Corn, sugarbeets and potatoes may require 100 pounds or more of potassium per acre. Always be sure that adequate nitrogen and phosphorus are applied when using potassium in your fertilizer program.

See University of Idaho Current Information Series fertilizer guides for recommended potassium adequacy levels for each crop.

## 6.04

Q. When and how should potassium be applied for maximum effectiveness?

A. Special operations are not necessary to apply potassium. Some studies have shown an advantage to banding while other studies have shown broadcasting to be equally effective. The most cost effective method will be to blend potassium with your other materials so it can be applied with nitrogen and phosphorus. Potassium fertilizers may, like nitrogen, cause stand damage when applied with the seed, so be sure to follow guidelines for appropriate rates (see question 3.08).

## 6.05

Q. Should I be using potassium on forage crops?

A. Forage crops have a higher potassium requirement than cereal crops. Potassium removal by cereal grains (straw not removed) is only about 20 pounds/acre of $K_2O$ compared to 100 to 200 pounds/acre for perennial forage crops. On the other hand, perennial forages appear to be more efficient at taking up potassium from marginally deficient soil. This improved efficiency is a result of a deeper and more extensive root system and more time for uptake by forages. As a result, perennial forages tend to be less prone to deficiency than cereal crops on marginally deficient soils. However, when potassium deficiencies occur on forage crops, higher rates of application are required than for cereals.

See University of Idaho Current Information Series for recommended potassium sufficiency levels for alfalfa (No. 827) and irrigated pasture (No. 392).

## 6.06

Q. How much potassium is needed by a potato crop?

A. Potatoes are heavy users of potassium. A 600 cwt/acre potato crop will remove approximately 400 pounds nitrogen, 47 pounds phosphorus and 596 pounds of potassium. Roughly half of the potassium is located in the vines of a 600 cwt/acre crop; much of the remainder is found in the tubers.

See University of Idaho Current Information Series 261, "Potatoes."

# Section 7. Sulfur and Micronutrients

## 7.01

Q. Should I be using sulfur and micronutrients on my crops?

A. Sulfur and micronutrient deficiencies are usually limited to relatively small geographic areas and specific crop and soil combinations. If you are applying adequate nitrogen, phosphorus and potassium and think yields are still limited by nutrition, consider the following steps before "shotgunning" micronutrients:

1. Make sure yield isn't limited by something other than nutrients. Look at soil properties, weeds, diseases, variety selection, average irrigation water nutrient content, quality and scheduling and other management factors.
2. Conduct a thorough soil analysis to rule out pH, salinity, sodium or other chemical problems. Then look at the soil test levels for plant nutrients.
3. Check for plant symptoms of nutrient deficiency. Visual symptoms are often confused with disease and other stress damage. Plant tissue analysis can be helpful in identifying specific nutrient problems.

If you have gone through these steps and still think the problem is sulfur or a micronutrient, try some test strips. Compare a strip treated with an adequate NPK package to a strip treated with one micronutrient added to the N, P and K.

## 7.02

Q. How widespread is sulfur deficiency?

A. Sulfur deficiency is most common in soils developed under forests and in coarse-textured or excessively drained soils. However, there are many exceptions. Northern Idaho and the mountain valleys of southern and eastern Idaho are likely areas for sulfur deficiency. Areas in southern Idaho irrigated with Snake River water should be sulfur-sufficient as this water contains considerable plant available sulfur. Sulfur deficiency is rare in other areas but occurs on a localized basis. Some soils are deficient in the topsoil but contain enough sulfur in the subsoil to meet crop requirements.

## 7.03

Q. How can I identify a sulfur deficiency?

A. A soil test will indicate a possible sulfur response. Sulfur will not be needed at a soil sulfate-sulfur ($SO_4$-S) test level of more than 8 ppm in the 0- to 12-inch depth or 10 ppm sulfate-sulfur in the 0- to 9-inch soil depth sample. Soils testing low (less than 3 to 5 ppm) are likely to respond to sulfur additions. Soils testing between these two levels may respond either positively or not at all to sulfur additions, depending on the crop, climatic conditions and the history of responses in the area. Unfortunately, the soil test for sulfur is not always indicative of crop responses. In many cases, a response is difficult to predict.

Plant tissue tests have been used successfully to identify sulfur deficiency. The best test is to examine the ratio of total nitrogen to total sulfur. Sulfur-deficient plants will have a N/S ratio greater than 13 to 15.

You should also look for visual symptoms of sulfur deficiency. Deficient areas are often "spotty" in appearance. Deficient plants are stunted and yellow, similar in appearance to N-deficient plants. A narrow strip of sulfur fertilizer across a field gives a reasonably accurate visual test. Even with modest yield response, treated plants will have a slightly darker color.

## 7.04

Q. How much sulfur is required to correct a deficiency?

A. As little as 10 to 15 pounds of sulfur per acre has corrected severe deficiency in cereal grains. Legume hay and oilseed crop deficiencies are corrected with 20 to 30 pounds of sulfur per acre. For most grass crops, including cereal grains, sulfur deficiency appears only when nitrogen fertilizer is used. In these cases, 1 part of sulfur for each 10 parts of nitrogen fertilizer will usually correct the deficiency. Use a S/N ratio of 1 to 5 for forage legumes and oilseed crops.

## 7.05

Q. Are all sulfur fertilizer sources equally available to crops?

A. No. Conventional sulfur fertilizers have sulfate ($SO_4^{=}$) as the base, which is immediately available to crops. Examples of available fertilizers are ammonium sulfate (21-0-0-24) and ammonium phosphate-sulfate (16-20-0-15). Several fertilizers based on elemental sulfur are available. Some of them are converted to plant-available forms slowly, and it may take months or even years before benefit appears in the crop. Finely ground elemental sulfur will become partially available in the growing season of the year of application. Elemental sulfur containing bentonite (0-0-0-90) will be about 30 percent available the year of application. Liquid fertilizers containing ammonium thiosulfate are all available the growing season they are applied.

## 7.06

Q. Will sulfur cure problems with high soil pH?

A. Yes, if applied at adequate rates. Sulfur is often used as an amendment to treat soils with high pH (usually pH values in excess of 8.3), especially when the problem is caused by sodium. The quantity of sulfur required for such treatments is usually from ½ ton to several tons per acre. Fertilizer applications of sulfur are usually less than 30 pounds per acre. Sulfur application at normal fertilizer rates will have a negligible effect on soil pH. Sulfur will not correct salinity problems in soil.

## 7.07

Q. Should I be concerned about micronutrient deficiencies?

A. Micronutrient problems are usually restricted to specific micronutrient-crop-locality combinations. Micronutrients should not be added unless the requirement for major nutrients is satisfied and then only when a specific deficiency is identified by soil or plant tissue testing or field tests.

## 7.08

Q. When can I expect a response to zinc?

A. Potatoes and beans are particularly sensitive to zinc deficiency. Corn and sugarbeets show inconsistent responses. Few cereal grain responses to zinc have been documented. Zinc deficiency occurs where soils contain large amounts of free calcium carbonate (lime) near the surface. This is often due to exposure of the subsoil by plowing, erosion or leveling. Extremely high levels of phosphorus may also induce zinc deficiency.

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