Nitrogen Fertilizers

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NITROGEN FERTILIZED
NO FERTILIZER
at
200# per Acre
8" - 6" - 4" - 2"

Cooperative Extension Work in Agriculture and Home Economics, F. E. Price, director.
Oregon State College and the United States Department of Agriculture cooperating.
NITROGEN FERTILIZERS

Percent Nitrogen
0 - 10 - 20 - 30 - 40 - 50 - 60 - 70 - 80 - 90

Ammonium Sulfate
Ammonium Nitrate
16-20 + 20% P2O5
11-48 + 48% P2O5
Urea
Sodium Nitrate
Calcium Nitrate
Cyanamid
Anhydrous Ammonia
Aqueous Ammonia

Dried Blood
Meat Meal
Bone Meal + 7 to 20% P2O5
Sewage Sludge

- Readily Available - Slowly Available
Nitrogen is an essential plant food that is often the limiting factor in crop production in Oregon. Nature provides available nitrogen for plant growth in the soil from decaying plant and animal matter. The atmosphere is 80 per cent nitrogen, but in this gaseous form it cannot be used directly by plants. Some nitrogen is converted from the air to a usable form by the bacteria found in the nodules on the roots of legumes. Certain soil organisms also have the ability to fix nitrogen for use by plants.

For many years the use of legumes and barnyard manure were the only known methods of increasing or maintaining the nitrogen supply in the soil. These methods are still good and should be continued. Commercial fertilizers carrying nitrogen in a readily available form, however, can be used with profit on most crops.

Nitrogen fertilizer does the following:

- Stimulates growth of nonlegumes.
- Increases the active organic-matter supply of the soil by speeding up the decomposition of dead roots.
- Provides available nitrogen for both grass and legume growth when the soil temperature is too low or the soil is too wet for natural nitrification processes.
- Helps get new legume seedings started before they are able to take nitrogen from the air.
- Provides available nitrogen for both grasses and legumes when the soil is worn out or eroded to the point that natural nitrification processes will not take place normally.
- Aids decomposition of straw and other crop residues.
- Increases the protein content of grass, grain, corn, and other nonlegume forage plants.
- Helps the plant, through increased growth caused by nitrogen, to make use of other plant foods already in the soil or applied as commercial fertilizer.

Cover picture

Ammonium sulphate applied in February at the rate of 200 pounds to the acre had at least doubled the growth of English rye grass and subclover in this field by April 15.
The use of commercial nitrogen is only part of a good soil management program. The increased yield will draw heavily on other mineral plant foods increasing the chances for profit through the use of other materials. When there is plenty of nitrogen in the soil, more moisture can be utilized for increased crop production. This latter point is important to the irrigation farmer.

The most common chemical nitrogen fertilizers sold in Oregon are discussed on the following pages.

**Ammonium Sulphate**

Pure ammonium sulphate contains 21.2 per cent nitrogen and 24.2 per cent sulphur. The ammonium sulphate sold for fertilizer has a guaranteed analysis of 20 to 21 per cent nitrogen in the ammonia (NH₃) form. It is a fine crystalline salt varying in color from white through various shades of gray.

All of the nitrogen in ammonium sulphate, sometimes called sulphate of ammonia, is in the ammonia form. Ammonia nitrogen does not leach out of the soil as readily as nitrate nitrogen. For this reason it is a very good source of nitrogen, especially in the irrigated sections of the state. Tests with ammonium sulphate in the Columbia Basin wheat area have shown that it is also a good source of nitrogen in that area.

For many years it was thought that all field crops used nitrate nitrogen exclusively and that all ammonia nitrogen had to be converted into the nitrate form by soil organisms before it could be used by plants. Research in the last few years has shown that many plants use some nitrogen in the ammonia form. Young plants, seedlings, absorb more ammonia nitrogen than older plants; therefore, ammonium sulphate and other ammonia fertilizers are especially good at seeding time.

Ammonium sulphate is an acid residue fertilizer and thus increases acidity of the soil. This is a distinct disadvantage in western Oregon where the soils are already acid. Much research has been done on this subject and the results of this work show that the continuous use of ammonium sulphate without lime in humid regions may result in the production of compounds in the soil that are toxic to crops. On alkaline soils of eastern Oregon the acid reaction of ammonium sulphate is desirable.

In western Oregon where the soils are already acid, the acidity produced by 100 pounds of ammonium sulphate could be neutralized by an application of 100 pounds of high-test lime. In other words, if 400 pounds of ammonium sulphate is applied annually, one ton of high-test lime should be applied every five years to maintain the soil
at the same pH level. If the soil is already acid, additional lime should be applied to raise the pH to between 6.0 and 6.5 (lime requirement of less than one ton per acre with the red color test) in order to obtain the maximum production of most crops.

Ammonium sulphate should not be mixed with superphosphate on the farm because a chemical reaction takes place that often results in a gummy mess in the fertilizer spreader. If it is mixed and allowed to stand, it hardens. Commercial mixing plants take advantage of this chemical reaction by letting the mixture stand until it is hard and then regrinding it. Once the mixture is completely dried and ground, it does not draw water and cake again providing it is stored in a dry place.

Rye grass growers say "more growth, more seed." The yield from the plot treated with ammonium sulphate, 300 pounds to the acre, should be more than double the yield on the unfertilized plot.

**Ammonium Nitrate**

Ammonium nitrate sold as fertilizer contains 32.5 to 33.5 per cent nitrogen. One-half of the nitrogen, about 16.5 per cent, is in the ammonia (NH₃) form and the other half is in the nitrate (NO₃) form.

The ammonium nitrate on the market now is granular and varies in color from white to pink. Pure ammonium nitrate is a white, crystalline material that draws moisture readily and cakes so badly that it cannot be applied with a regular fertilizer drill. To overcome this condition, manufacturers have developed graining processes.
Most commercial ammonium nitrate is a white granular material. It is readily soluble in water and can be spread by putting it through the sprinkler irrigation system.

The Tennessee Valley Authority manufactures ammonium nitrate that has a granular structure and is pink in color. The pink color is due to petrolatum and clay coating on the individual particles. This product is not as water soluble as the other brands of ammonium nitrate sold in Oregon and will cause some trouble when spread through the sprinkler irrigation system because the waxy material continually clogs the sprinklers.

Ammonium nitrate does not cake if it is stored in a dry place and if the bags are not broken. It is easy to spread through a conventional fertilizer spreader. However, when the bags are opened the material will take moisture from the air. During dry weather the ammonium nitrate flows freely, but when the air is moist, the material becomes sticky and feeds slowly. Spreading equipment should be adjusted accordingly. The cost per unit of available nitrogen (N) is usually a little less than in ammonium sulphate.

Ammonium nitrate is a quick-acting fertilizer because one-half of the nitrogen is in the nitrate form ready to be taken up by the plant. If the nitrate nitrogen is not used by the plant soon after the fertilizer is applied, it may be leached out of the root zone if there is a downward movement of water in the soil due to precipitation or overirrigation. Ammonium nitrate can be used to a good advantage during the growing season when extra nitrogen is urgently needed.

Both plots of rye grass were fertilized on the same day with identical amounts of available nitrogen, 63 pounds to the acre (ammonium sulphate, 300 pounds per acre; ammonium nitrate, 188 pounds per acre). The ammonium sulphate has been ahead from the start.
NITROGEN FERTILIZER

If ammonium nitrate and other fertilizers are mixed together on the farm, the mixing should be done in the open because some ammonia may be liberated as a gas. Ammonium nitrate can be ignited or detonated if it is exposed to the atmosphere under certain conditions that are not fully understood. Therefore, it should be handled carefully.

Ammonium nitrate is an acid residue fertilizer. About 60 pounds of high-test limestone will neutralize the acidity produced by 100 pounds of ammonium nitrate.

Ammo-phos

Ammo-phos is the abbreviation for ammonium phosphate, a material containing both nitrogen and phosphorus. Several combinations can be made but only two are on the market in Oregon. They are 11-48 and 16-20.

11-48 is manufactured by combining ammonia and phosphoric acid. As the common name 11-48 indicates, this material contains 11 per cent available nitrogen in the ammonia form and 48 per cent available \( \text{P}_2\text{O}_5 \).

16-20 is manufactured by combining phosphoric acid, sulphuric acid, and ammonia. It contains 16 per cent available nitrogen in the ammonia form, 20 per cent \( \text{P}_2\text{O}_5 \), and about 14 per cent sulphur in the sulphate form.

Many farmers and agricultural workers have noticed that 11-48 and 16-20 give better results on most crops than comparable amounts of straight nitrogen fertilizer and superphosphate. There are two reasons or theories that may explain why 11-48 and 16-20 are good fertilizers.

In the first place, from 85 to 90 per cent of the available \( \text{P}_2\text{O}_5 \) in either 11-48 or 16-20 is soluble in water. This high percentage of water soluble phosphate is more mobile in the soil than the phosphate in superphosphate. Another explanation may be that some of the nitrogen in 11-48 and 16-20 is utilized by plants in the ammonia form and the phosphate in combination with ammonia is taken up at the same time. This stands to reason since it is known that most plants will use some nitrogen in the ammonia form, especially when they are young.

Both ammo-phos fertilizers are light gray in color and are in the pellet or granular form. They do not readily absorb moisture from the air so they can be stored for some time and are very easy to spread.
Ammonium phosphate, 16-20, increased the forage yield from this alta fescue and subterranean clover pasture. The left side was treated with 200 pounds to the acre in March while the right side was left unfertilized.

11-48 is a very good fertilizer to apply at seeding time on new seedings of legumes or grass and legume mixtures. For example: 200 pounds per acre of 11-48 will supply about the right amount of nitrogen and phosphate for a new grass and legume pasture seeding. One thing to remember, however, is the fact that 11-48 does not contain sulphur. If sulphur is needed, it will have to be applied as landplaster or elemental sulphur.

16-20 is a good fertilizer for grains, grasses, corn, potatoes, and many other crops. It is also a good fertilizer to use on established pastures, especially as an early fall application. Since 16-20 contains about 14 per cent sulphur in the sulphate form, it should also take care of the sulphur requirement.

Both 16-20 and 11-48 are acid residue fertilizers. It takes between 100 and 125 pounds of high-test lime to neutralize the acidity produced by 100 pounds of either 16-20 or 11-48.

Urea

At least one company manufactures a synthetic urea fertilizer. This is a semigranular product analyzing 44 per cent nitrogen, an amount greater than that found in any other commercial solid nitrogenous fertilizer.
The urea in this product is identical in chemical composition with that found in animal urine. This material is completely soluble in the soil solution, but it must be converted to ammonia and nitrates before it can be utilized by most crops. Urea is rapidly converted into ammonia products when the soil is warm enough for bacterial activity. Response from an application of urea may be slow during cold weather.

Since the conversion of urea to usable nitrogen depends to a large degree on soil bacteria, it is very important that the soil be well supplied with active bacteria. For this reason, urea will be much more effective on good soil that has a pH between 5.5 and 7 (two-ton lime requirement or less) because there is more bacterial activity in soils in this pH range.

Urea produces less acidity in the soil than ammonium sulphate or ammo-phos (16-20 or 11-48). Seventy pounds of high-grade limestone will neutralize the acidity produced by 100 pounds of urea.

Urea is a good fertilizer to apply before seeding. It should not be applied in too large amounts at any one time close to germinating seeds or plant roots because bacteria in the soil rapidly convert urea into urea compounds that can injure seedlings and plant roots if it is in direct contact with them. Urea applied before planting, however, is rapidly converted to ammonia by the soil bacteria and the seedlings will utilize the ammonia nitrogen. The ammonia that is not used by
the seedlings is converted to nitrates to be used by the growing plants. After the nitrogen in urea is converted to ammonia, it is resistant to leaching until it is further converted to nitrate nitrogen by soil organisms.

**Sodium Nitrate**

Sodium nitrate has been used in the United States as a source of nitrogen for a longer time than any other inorganic nitrogenous fertilizer. It has been mined in Chile for more than a century. In recent years it also has been produced from synthetic ammonia and sodium carbonate.

Sodium nitrate sold as a fertilizer usually contains about 16 per cent available nitrogen, all in the nitrate (NO₃⁻) form. All of the nitrogen is in the nitrate form; so it is immediately available to a growing crop. Since it goes into solution readily and is immediately available, it is also subject to loss by leaching. It should not be applied in the fall or early spring because all of the nitrate nitrogen that is not taken up by the crop within a short period of time after the fertilizer is applied will probably be leached out of the root zone. Experimental results from other areas show that two to ten times as much nitrogen was leached from the soil when sodium nitrate was used in comparison with an equal amount of nitrogen applied as ammonium sulphate. Sodium nitrate is good for side dressings and late season top dressings on growing crops when rapidly available nitrogen is needed.

Experiments have shown that heavy applications of sodium nitrate can seriously reduce the permeability of the soil. This is not likely to happen in western Oregon when normal applications of 100 to 300 pounds per acre are made once or twice a year. It is possible, however, in eastern Oregon if sodium nitrate is used on nonirrigated land or land that is poorly drained.

Sodium nitrate is a basic fertilizer and may reduce the acidity slightly. It should not be applied, however, as a substitute for lime.

**Calcium Nitrate**

Calcium nitrate, sometimes called “Norwegian saltpeter,” is now being sold by several Oregon dealers.

Calcium nitrate sold as a commercial nitrogen fertilizer analyzes about 15.5 per cent available nitrogen in the nitrate form. It is granular in structure and has good spreading qualities, but has a tendency to draw moisture when it is exposed to the air. For this
reason, it is shipped in burlap bags with a paper lining cemented to the bag with asphalt. It should be spread on a dry day when the relative humidity is less than 40 per cent. Calcium nitrate coming in direct contact with leather causes the leather to shrink so the farmers should have their shoes well greased when they apply it. The bags should not be opened until the material is to be spread.

Calcium nitrate is completely soluble in water and the nitrogen in it is readily available to plants. Tests conducted at the Oregon State College Experiment Station indicate that calcium nitrate produces about the same results as other nitrate fertilizers. Since all of the nitrogen is in the nitrate form, it is subject to leaching.

Calcium nitrate is a basic fertilizer and, therefore, will not increase the acidity of the soil. Since it contains about 20 per cent soluble calcium, it has some advantages over other nitrogen fertilizers, especially during the growing season when the plants take most of their nitrogen in the nitrate form because it will neutralize some of the acid residues left by ammonium sulphate or other ammonia fertilizers that may have been used earlier.

**Cyanamid**

Calcium cyanamid is sold on the market under various trade names. Most of the cyanamid sold in Oregon contains 20 to 22 per cent nitrogen. It is black in color because it contains free carbon. Calcium cyanamid is marketed in both powdered and granular form. The granular form is much easier to handle than the powdered form.

Bags of calcium cyanamid should not be opened until it is to be spread on the land. It absorbs water and carbon dioxide if it is exposed to the atmosphere for long periods of time.

The nitrogen in calcium cyanamid is linked up with carbon in the form of cyanamid \((\text{CN}_2)\). When it is applied to a neutral or acid soil, the calcium cyanamid goes into solution in the soil water and is converted into urea. This conversion usually takes place in a neutral or acid soil from two to seven days after the calcium cyanamid is applied. After the cyanamid is converted to urea, it is further converted to usable nitrogen by soil bacteria as explained in the discussion on urea. When calcium cyanamid is applied to an alkaline soil, the cyanamid is converted into urea and dicyanodiamide. The main objection to this reaction in alkaline soils is the fact that the dicyanodiamide is more stable and does not break down into usable nitrogen as readily as does the original cyanamid.

Calcium cyanamid is toxic to plants if it comes in direct contact with the leaves, seeds, or roots before it is converted to usable forms.
Nitrogen fertilizer paid good dividends on this field of Chewings fescue. The fescue on the left side of the picture received an application of 100 pounds to the acre of ammonium sulphate in early October plus an application of 400 pounds to the acre of calcium cyanamid in February. This area produced over 600 pounds of clean seed to the acre while the fescue on the right side that received no nitrogen produced less than half that amount—yielding 250 pounds of seed per acre.

of nitrogen (ammonia and nitrate nitrogen). Applications of calcium cyanamid partly sterilizes the soil by killing soil bacteria, worms, molds, and other living organisms in the soil. The degree of sterilization depends on the amount of calcium cyanamid applied per acre. For this reason, calcium cyanamid is sometimes used to kill molds and disease organisms in the soil. It is used also as a dust to kill weeds.

Calcium cyanamid is a basic fertilizer. One hundred pounds of this material has about the same neutralizing value as 63 pounds of high-test ground limestone. It is obvious from the above discussion on the toxic effect of calcium cyanamid that it would be impractical to use this product in place of lime. These basic properties, however, are of some value in western Oregon.
Applications of calcium cyanamid before the soil is worked in preparation for a new seeding are very satisfactory. On well-drained soils it can be applied before plowing. If it is applied on the surface, it should be spread evenly rather than placed in bands. This can be accomplished with an ordinary box-type spreader by placing a splash board under the holes so that the material falls on this board and spreads out evenly before reaching the ground. Some spreaders are equipped with a splash board when they come from the factory. It is also a good idea to mix calcium cyanamid with the top three or four inches of soil. This material should be applied ahead of planting so that the cyanamid will be changed to urea and then to ammonia nitrogen before it comes in contact with the seed. At least three days prior to planting should be allowed for every 100 pounds per acre of material applied. In other words, if calcium cyanamid is applied on fertile soil at the rate of 300 pounds to the acre, it should be applied nine days before planting.

The conversion of cyanamid to ammonia and nitrate nitrogen takes place much more rapidly in fertile soils high in organic matter than it does in worn out soils or sandy soils low in organic matter. Calcium cyanamid should be applied to soils low in organic matter at least ten days before planting.

There is a great danger of crop injury if straight calcium cyanamid is used as a side dressing on growing crops. If the cyanamid comes in direct contact with the roots they are apt to be injured. Calcium cyanamid is often used in mixed fertilizers, but the amount used in the mixture is usually small enough to permit use of the mixture as a side dressing without fear of toxicity. Calcium cyanamid can be applied to grains and grasses early in the spring without too much danger of crop injury.

The nitrogen in calcium cyanamid is just as resistant to leaching as the nitrogen in urea and ammonia fertilizers.

**Anhydrous Ammonia**

Ammonia is formed by combining nitrogen from the air with some source of hydrogen as the first step in manufacturing most forms of synthetic nitrogen fertilizer. Ammonia is commonly known as the gas used in commercial refrigeration. Under atmospheric conditions it is a gas but it can be compressed to a liquid.

The compressed ammonia weighs five pounds per gallon and carries 81 to 82 per cent nitrogen, all in the $\text{NH}_3$ form. Each gallon then contains 4.1 pounds of nitrogen.

The conversion of ammonia to conventional forms of nitrogen fertilizer such as ammonium nitrate, ammonium sulphate, urea, or
sodium nitrate requires additional expensive processes and often other raw materials.

During the past twenty years research has developed methods of using ammonia as a direct fertilizer. It was used first in a practical way in California. Currently it is being used extensively there and in some of the southern states. It is available now in certain sections of Oregon.

In areas adjacent to manufacturing plants ammonia is the cheapest source of available nitrogen. In Oregon the price is competitive with other materials. It probably cannot be expected that prices will be comparable to those in the southern states because of Oregon's substantially higher transportation and distribution costs.

Ammonia is transported and handled from the manufacturing plant as a liquid. This means transportation in tank cars built to confine the material under a pressure of 150 pounds per square inch. These tank cars deliver the material to the point for retail distribution where it is transferred to pressure cylinders having the capacity of 150 to 1,500 pounds or more of the liquid ammonia still under pressure. Because of the cost of pressure containers, substantial storage at the retail points or on the farm is impractical.

Ammonia is now used for direct application by two different methods. Direct injection into the soil has the widest adaptation. With this method, the ammonia is released through a chisel point traveling through the soil at a depth of four inches or more. Usually a number of chisel points are mounted on a row-type cultivator, field cultivator or similar implement. The points can be spaced at twelve-inch intervals or wider widths depending on the crop to be fertilized. By a system of pipes and hose any number of points can be connected to a field container carrying the ammonia under pressure. This container may be mounted on the cultivator or can be mounted on a trailer. By the use of orifices of the proper size the gas can be released to each chisel point at a constant flow. This permits the accurate application of any desired quantity of nitrogen providing the implement is operated at a constant speed.

As the pressure is released in the chisel points, the liquid ammonia changes to a gas and is absorbed immediately by the soil.

The injection of ammonia is limited to applications made in advance of seeding or as side dressings made at a time when the deep penetration of the chisel point does not seriously damage the crop. Ammonia appears especially well adapted to the summer fallow wheat area because of the long period during which nitrogen applications can be made.
With the other method of application, ammonia is released from the pressure cylinders into irrigation head ditches. It is then carried with the irrigation water through the rills or furrows and is taken into the soil. Obviously, this method of application is practical only where full control of the irrigation water is possible.

The direct injection of ammonia or use in irrigation water requires the services of trained personnel as well as specialized equipment. For this reason the price of the material in Oregon is based on the applied basis—so much per pound in the ground.

Anhydrous ammonia is a newcomer but, judging from results, it is here to stay. Trials to compare ammonia with other nitrogen carriers have been made by the Oregon Experiment Station and by interested farmers. Yields indicate that the nitrogen supplied in this gaseous form gives a response equal to the nitrogen supplied in other carriers and often markedly better. Whether or not nitrogen as a plant food supplied in anhydrous ammonia has any advantage over other chemical forms remains to be proved, but there are some reasons why the ammonia can give better results particularly in nonirrigated areas. When injected into the soil the anhydrous ammonia is placed in ready reach of the plant roots in moist soil. Solid materials are often stranded high and dry. Deep application places the nitrogen where it cannot be carried away by surface run-off. As another advantage the ammonia can be applied at a uniform rate. It is difficult if not impossible to make a uniform application of solid materials. When supplies are available, ammonia can become a popular and profitable nitrogen carrier in Oregon.

**Aqueous Ammonia**

Ammonia is available also in Oregon in a water solution. Solutions may carry from 20 to 24 per cent nitrogen. Water solutions of ammonia are unstable and rapidly lose the ammonia content when exposed to the atmosphere. Application methods must follow the same principle used in application of anhydrous ammonia.

The material is injected into the soil. The basic equipment is the same as described for anhydrous ammonia except that to maintain a constant pressure it is necessary that the material be pumped to the chisel points. Aqueous ammonia may also be applied by metering the material into irrigation water used for rill irrigation.

Anhydrous and aqueous ammonia leave an acid reaction in the soil and require about the same amount of lime for neutralization as ammonium sulphate.
Application Through Sprinklers

All of the solid nitrogen fertilizers discussed so far, with the exception of cyanamid, can be applied through sprinkler irrigation equipment. Ammonia and urea forms of nitrogen should be applied early in the irrigation set. Nitrate nitrogen should be applied during the last 30 minutes.

Neither aqueous nor anhydrous ammonia should be used through sprinkler irrigation equipment because loss of nitrogen would be high as the water fell through the air. Furthermore, the material could cause serious burning.

Note: Soluble nitrogen fertilizers can be applied through the sprinkler irrigation system. See Oregon State College Extension Bulletin 626, “The Solution Method of Applying Ammonium Nitrate.”

Nitrogen in Complete Fertilizers

The nitrogen carried in complete fertilizers may be supplied by any one or more of the nitrogen-carrying materials described. If most of the nitrogen is supplied in the nitrate form, precautions should be taken against possible leaching. If substantial quantities of nitrogen are applied as cyanamid or urea, ample time should be allowed for these materials to become available in the soil.

By state law, all fertilizers sold on the market in Oregon must have a tag showing the guaranteed percentage of nitrogen, phosphate ($P_2O_5$), and potash ($K_2O$) contained. These tags also show the different fertilizer materials used in the mixture, such as ammonium sulphate, 16-20, sulphate of potash, etc.

Organic Nitrogen Fertilizers

Dried blood, meat meal, bone meal, and other byproducts of the packing industry are sometimes used as nitrogen fertilizers. Most of these products, however, are used in complete fertilizer mixtures or in high-protein animal feeds. The nitrogen content of these materials varies greatly and is considerably less than the nitrogen content of most of the inorganic or mineral nitrogen fertilizers. The organic nitrogen fertilizers from plant and animal origin are not soluble in water.

Activated sewage sludge is another low-grade carrier of nitrogen that will be more readily available in the future. In order to eliminate stream pollution, the larger cities and towns in Oregon are building modern sewage disposal plants and many of them will probably market treated sewage sludge as fertilizer.