Nitrogen - For years land managers, from the farmer to the scientist, have disputed the benefits of organic versus inorganic nitrogen. There is no dispute that nitrogen is an essential element to plants. There is also no argument that plants can't tell the difference between organic and chemical nitrogen. The controversy is essentially about carbon.

Carbon in the soil is in the form of organic matter and provides energy, either directly or indirectly, to all heterotrophs (i.e. living organisms that use carbon compounds directly from plants and other organisms). Soil carbon is produced by autotrophic organisms, such as plants and algae that can fix carbon from the atmosphere by using energy from the sun. The carbon compounds produced by autotrophs eventually become part of a vast warehouse of energy and protein known as soil organic matter. This warehouse functions beneficially in hundreds of different ways, but one essential purpose is to provide energy to soil life.

When fresh organic matter (OM) hits the soil, decay begins almost immediately (during the seasons that microorganisms are active). What determines the speed at which OM is decomposed (with adequate air and moisture) is the carbon to nitrogen ratio (C:N) of the OM. The C:N ratio is always measured as x parts carbon to one part nitrogen. If the C:N ratio is high (i.e. high carbon) as in straw or wood chips, decomposition occurs slowly. Also, the nitrogen is temporarily commandeered by bacteria from other sources for the formulation of proteins. If the original organic litter has a low C:N ratio, as in grass clippings or animal wastes, decomposition will occur more rapidly and nitrogen is made available to other organisms. Each time the components of OM are digested by heterotrophs some energy is used, and carbon is oxidized into carbon dioxide (CO_2), which is then released back into the atmosphere.

Carbon cycles from the atmosphere to the soil and back into the atmosphere. Carbon dioxide in the atmosphere is absorbed by plants and transformed into carbohydrates, proteins and other organic compounds. These compounds are essentially storage batteries containing energy that was originally derived from the sun. If animals consume the plant, some of the original energy is used and CO_2 is released back into the atmosphere. If another animal consumes the animal, more of the energy is used and more CO_2 is released. Eventually the remaining energy is returned to the soil in the form of animal residues, where decay organisms can use it. If plant residues are introduced directly to the soil without prior consumption, more energy (i.e. carbon) will be available to soil microbes.

Nitrogen (N) serves the microbe as much as (or more than) it serves the plant. If there is only enough nitrogen in the soil for either the plant or the needs of bacteria, the bacteria will get it.

When inorganic nitrogen is applied to the soil it stimulates populations of both decay bacteria and plants. If used judiciously, it can have a synergistic effect with OM that increases overall nitrogen efficiency. Large populations of microbes can immobilize a significant portion of the inorganic N by converting it to protein and stabilizing it into a non-leachable, non-volatile organic nitrogen. When those organisms die, other microbes decompose them and the N is slowly mineralized back into plant food. However, in order for soil microorganisms to accomplish this, they must have energy in the form of organic carbon.

In 1950, a ton of inorganic fertilizer would, on average, boost yields of grain by forty-six tons. By the early 1980's, the gain from that same ton of fertilizer was only thirteen tons of grain. The response difference is due largely to the depleted level of energy that is not being replaced by the inorganic inputs.

A solution to this problem is to use natural organic nitrogen whenever possible or small amounts of inorganic nitrogen mixed with sufficient quantities of OM such as compost, green manures or other sources of organic carbon. Natural organic nitrogen contains organic carbon that can replenish the soil's energy reserves. Carbon is an essential component in sustaining the cyclical nature of the soil system and can help balance the effect inorganic nitrogen has on the soil.

Stable compost, with a C:N ratio of approximately 15-20:1, has much to offer in terms of soil conditioning, including large populations of beneficial bacteria, essential nutrients, and plenty of carbon. However, its nitrogen analysis at 1-3 percent would mean applications of 1,500-4,400 lbs. to receive forty-four lbs. N per acre (one lb N/1,000ft^2). Compost is usually affordable, unless it has to be trucked over long distances, and it can be spread through most top dressing machines. Researchers at Cornell University and elsewhere have recently found that well aged compost (i.e. >two years) can also suppress many turf diseases.

Products that contain a C:N ratio higher than 25-30:1 are probably not appropriate nitrogen sources. If the C:N ratio is too high, the nitrogen content is not sufficient to sustain the growing populations of decomposition bacteria. In addition, other sources of soil nitrogen are temporarily depleted.

Meals ground from beans or seeds usually contain a C:N ratio of approximately 7:1 but if shells are mixed in, the carbon value can get higher. Animal by-products, such as feather meal, blood meal or leather meal contain somewhere between three and eight parts carbon to one part nitrogen.

The C:N ratio of raw manures varies considerably depending on the animal it is derived from, that animal's diet, and the type and amount of bedding that is mixed with it. Raw manures are an impractical source of nutrient for many crops. They are difficult to apply, are aesthetically displeasing, can offend one's olfactory senses, are often replete with weed seed, and contain nitrogen that is unstable. Composting manures prior to application, rather than using them raw, is a very practical solution.

Many companies are claiming that their products contain organic nitrogen; however, they are deriving it from urea based ingredients. Urea is synthetic organic nitrogen with a C:N ratio of 0.4:1, and offers very little carbon to the biological activity in the soil. It has just enough carbon to call it organic. Some companies mix inorganic nitrogen into fertilizer blends along with organic carbon from other sources. This combination can increase nitrogen efficiency if enough organic carbon is added. However, there is no set formula that determines the proper ratio. The C:N ratio in a natural soil system averages around 12:1. Natural organic nitrogen from plant and animal proteins ranges from three to eight parts carbon to one part nitrogen. No research was found that could quantify the ideal C:N ratio of fertilizers. Common sense dictates that C:N ratios somewhere between 12:1 (soil) and 3:1 (high N animal protein) would be appropriate.

Sources of organic nitrogen vary in C:N ratios; unfortunately, C:N information is usually not available on bagged, natural organic fertilizers. The only way to find the C:N ratio of organic fertilizer is either to test it oneself or ask the manufacturer to test it. Some companies may already know the C:N ratio of their products. Feeding nitrogen into the soil is absolutely necessary at times, but applying it without carbon can eventually cause many problems.

Natural organic sources of nitrogen are derived from proteins in plant and animal residues. The N in animal manures is used in large quantities by farmers for crops, and by manufacturers who compost or ferment and package the manures for sale at garden centers. Composting and fermentation chemically change the manure into a more stable form of fertilizer, but the change is accomplished by natural microorganisms with the resulting fertilizer still considered a natural organic product. Composted manures are an excellent amendment to soils because of the high percentage of organic matter they contain, but they must be used in larger quantities because of their relatively low nitrogen content. To small-scale gardeners (who have a tendency to overdose their soil with fertilizers), this is a preferred material.

Some manure products are being produced by a new process that combines partial composting and quick drying. The result is a dry, granular manure that has a higher nitrogen content. However, this process of *semi-composting* will not stabilize all the N into a non-volatile, organic form, and strong odors are often painfully evident once the bag is opened.

Other animal residues that contain nitrogen are blood meal, feather meal, hoof and horn meal, meat and bone meal and leather meal. Some dairy by-products such as dried whey also contain nitrogen. These products differ in nitrogen content but all have a much higher content than composted manures. Feathers and blood, for example, both contain approximately 12 percent N; blood will release the N much faster than feathers. The other animal by-products listed above contain between 5 percent and 10 percent N and release it at varying rates, depending mostly on how finely the products are ground.

Residues from plants that are high in protein are also useful as sources of nitrogen. Meals ground from beans or seeds such as peanut, cocoa or soy contain between 3 percent and 7 percent N. However, most of these products are primarily used in animal feeds and priced as protein, which can make them prohibitively expensive as fertilizer ingredients. Sometimes the vegetable protein meals used in organic fertilizers have been rejected for feed because of aflatoxins (natural toxins that are a danger to livestock but innocuous in the soil). This rejection makes the material more economically practical to use as a fertilizer.

The only source of natural inorganic (mineral) nitrogen is a deposit of sodium nitrate that occurs in the Atacama Desert, located in Northern Chile. Chilean Nitrate (so called) is mined and purified through a physical process and is shipped around the world. This natural nitrate of soda contains 16 percent soluble N. Unlike many inorganic salts, Chilean Nitrate does not acidify the soil. It actually has a slightly neutralizing effect on soil pH.

As mentioned earlier, the difference between synthetic inorganic and natural organic nitrogen is carbon. Carbon is the fuel from which all living organisms derive their energy. It is important to note that nitrogen is combined with carbon to form proteins. This carbon is necessary for all the other functions in the cycle to occur.