Nitrogen

ESSENTIAL ELEMENTS

THE FERTILIZER INSTITUTE

Did you know that about 80 percent of the air we breathe is nitrogen gas (N2)? In fact, every acre of land in the world is covered by about 75 million pounds of N from the 37,000 tons of N_2 in the atmosphere. Crop plants can use virtually none of that atmospheric N2 until it is changed by natural processes or by commercial fertilizer N production.

Through various biological or industrial processes of fixation, gaseous atmospheric N2 is changed to plant-usable forms: either ammonium or nitrate. Small amounts can be fixed by lightning and carried to the Earth's surface in rain or snow. It can be fixed by certain organisms in the soil and in nodules on legume roots. Industrial fixation supplies the millions of tons of commercially produced N fertilizers required to grow crops around the world.

Nitrogen is an essential nutrient because it is a part of the makeup of all plant and animal proteins. The nutritive value of the food we eat is largely dependent on having an adequate supply of N.

IPNI PHOTO: SHARMA AND KUMAR

Nitrogen deficient corn leaf.

Nitrogen in Plants

Nitrogen is required in greater quantities by crops than any of the other essential nutrients except potassium (K). Some crops take up more K than N. Table 1 shows how much N is required by a number of common crops. Inorganic nitrate and ammonium are the major forms of N taken up by plant roots.

Nitrogen in Soils

Although the amount of N stored in soil organic matter is large (often more than 1,000 lbs/A), the amount released and available for plant uptake is relatively small. Often, that release is not synchronized with plant demand. Very little N is found in rocks and minerals. Organic matter releases N slowly, the rate being controlled by soil microbial activity (influenced by temperature, moisture, pH and texture).

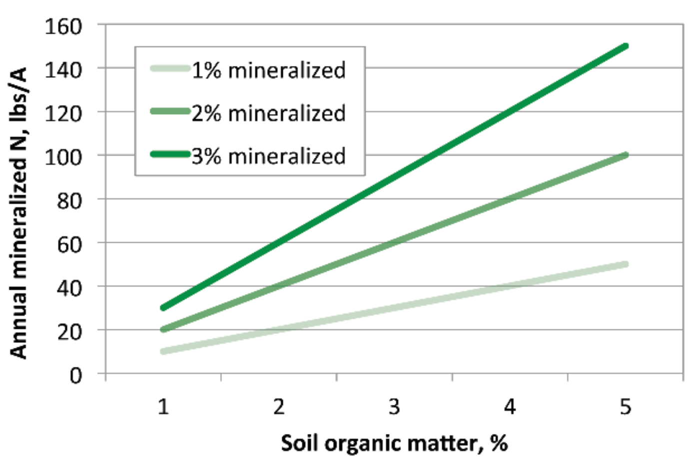
In general, about 20 to 30 lbs N/A are released annually for each 1 percent organic matter contained in the upper 6 to 7 inches of soil. One of the products of organic decomposition (mineralization) is ammonium, which can be held by the soil, taken up by crop plants, or converted to nitrate. The nitrate is used by plants, leached out of the root zone, or converted to gaseous N and lost back into the atmosphere. The conceptual relationship between plant-unavailable N (organic matter) and plant-available N (ammonium and nitrate), and soil temperature effects are illustrated in **Figures 1** and **2**.

Table 1. Crops are big users of nitrogen.

Crop	Yield Level	N uptake	N removal
		--- lb ---	
Alfalfa† (DM)	8 tons	432	408
Coastal Bermudagrass	8 tons	368	368
Corn	160 bu	160	107
Cotton	1,500 lb lint	180	96
Grain Sorghum	130 bu	143	86
Peanuts	4,000 lb	252	140
Potato	500 cwt	245	150
Rice	7,000 lb	110	89
Soybeans	60 bu	294	195
Tomatoes	40 tons	224	100
Wheat, Spring	60 bu	132	89
Wheat, Winter	60 bu	114	70

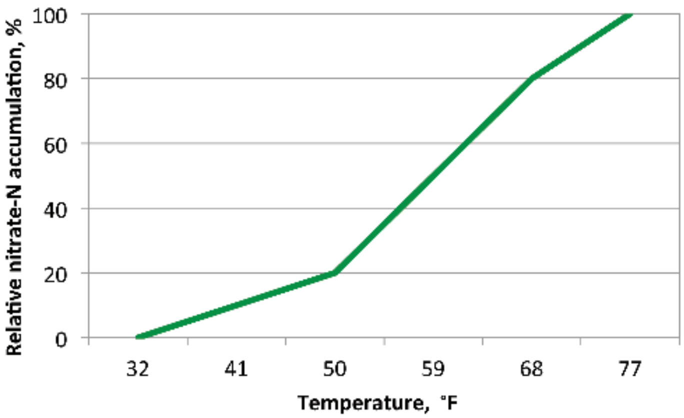
†Legumes get most of their N from air.
DM = dry matter (0% moisture) basis
For more crops, visit http://ipni.info/nutrientremoval

Figure 1. Conceptual example of the amount of inorganic N released (mineralized) from soil organic matter at three rates of microbial activity.



This information was originally developed by the International Plant Nutrition Institute.

Figure 2. Example of the effect of soil temperature on the rate of nitrate accumulation (nitrification) in soil in Illinois.[2]



Choosing a Nitrogen Fertilizer Source

Since most soils cannot provide sufficient quantities of N to support economically optimum crop growth and quality, commercial fertilizers are widely used to supplement crop needs. Manure, sewage sludge and other waste sources of N are acceptable as well, when they are available. However, those non-fertilizer sources can be difficult to manage and cannot be economically transported long distances. Choosing the correct N source should be based on several factors, including: availability, price, crop being fertilized, timing and methods of application, tillage systems, and risks and pathways for off-site losses. For plant nutrition, a unit of soluble N is the same, regardless of whether it came from fertilizer or organic matter. All N sources require careful stewardship to use them to their potential. Further, all N sources, if not properly managed, can pose a potential source for environmental losses, including nitrate accumulation in groundwater and surface water.

Nitrogen Deficiency Symptoms

An adequate supply of N is usually seen in most plants as a dark green color in leaves, caused by a high level of chlorophyll. A deficiency results in a yellowing (chlorosis) of the leaves because of inadequate chlorophyll. Deficiency symptoms appear first on older leaves and then develop on younger ones as the condition becomes more severe. Other symptoms of N deficiency may include:

- Stunted, spindly plants
- Less tillering in small grains
- Low protein content in seed and vegetative parts
- Fewer leaves
- Higher susceptibility to stress from weather, pests, and diseases

Crop Response to Nitrogen

The need for N fertilization is more common than for any other essential nutrient. Table 2 shows how corn yields and nitrogen use efficiency were increased with added N fertilizer and higher plant populations. Nitrogen fertilization is more profitable and environmentally friendly when used with other appropriate best management practices (BMPs).

Because crops are so responsive to additions of N, the optimum rate of N fertilization is changed relatively little by changes in either crop or fertilizer price. This is true as long as the crop exhibits responsiveness. The concept is illustrated in Table 3.

Appropriate N management—based on the 4R principles of using the right source at the right rate, right time, and right place—can optimize crop yields and returns, while reducing the risks of potential negative effects on the environment.

References

1. Ciampitti A. and T. Vyn. 2011. Field Crops Research 121:2-18.
2. University of Illinois. 2012. Illinois Agronomy Handbook. College of Agricultural, Consumer and Environmental Sciences.

Table 2. Higher corn population and nitrogen interact to increase yield and nitrogen use efficiency, averaged over two locations and four hybrids in Indiana.[1]

Population, plants/A	Grain yield (bu/a) at different rates, lb/A			Grain yield response to highest N rate, bu/A
	0	150	300	
22,000	100	120	127	27
32,000	127 (31)†	152 (38)	169 (49)	42
42,000	129 (21)	161 (47)	180 (30)	51
Response to highest population, bu/A	29	41	53	

†N use efficiency (shown in parentheses) calculated as percent apparent fertilizer N recovery efficiency: [(N uptake with N minus N uptake at zero N rate)/applied N rate] x 100.

Table 3. Economically optimum nitrogen rates change little with corn and fertilizer price changes.

Corn price, $/bu	Price of N, cents/lb			
	20	40	60	80
	Optimum N rates on corn, lb/A			
2.80	162	153	145	136
3.92	164	158	151	145
5.04	165	160	155	150