

# Have You Thought about Nitrogen Mineralization Lately?

by Neil W. Christensen

Probably not, but maybe you should — you might increase profits while protecting Oregon's water quality. Mineralization is the conversion of an element from an organic to an inorganic state as the result of microbial activity. Specifically, *N Mineralization* is transformation of N in soil from the organic state (*i.e.*, humus, crop residues) into inorganic forms, primarily ammonium ( $\text{NH}_4^+$ ). This process is performed by soil organisms meeting their needs for carbon and energy by decomposing nitrogen-containing organic substances. Acting in the opposite direction, *N Immobilization* is the process by which inorganic nitrogen such as ammonium ( $\text{NH}_4^+$ ) or nitrate ( $\text{NO}_3^-$ ) is converted into organic forms, also by soil microbes. The net difference between these two opposing processes determines whether soil microbes are providing N for crops (*net mineralization*) or competing with plants for nitrogen (*net immobilization*) at any given time.

**Why** are these processes important? Mineralization is essential because most of the nitrogen in soils is unavailable to higher plants. Organically combined nitrogen in soil organic matter or crop residues is not available to plants until it is converted to ammonium ( $\text{NH}_4^+$ ) or nitrate ( $\text{NO}_3^-$ ). Our studies show that only 1 to 5 % of the 2000 lb. N per acre in the top six inches of a Woodburn silt loam soil is available to wheat plants as inorganic nitrogen. Using  $^{15}\text{N}$ , a non-radioactive isotope, we also learned that 1.8 to 2.6 % of the nitrogen in soil organic matter and 5 % of the nitrogen in wheat residue become available to a winter wheat crop in the Willamette Valley. These seemingly low rates of net mineralization can, in many cases, provide a substantial proportion of a crop's requirement for nitrogen. Equally important, but less well recognized, is the fact that low rates of net mineralization act as a governor, or automatic control, that prevents release of excessive quantities of nitrogen that could harm crops and pollute groundwater. Farmers and their advisors face the challenge of accurately estimating the amount of nitrogen fertilizer needed to make up the difference between the amount of nitrogen supplied by the soil and the amount of nitrogen required by the crop for maximum economic yield.

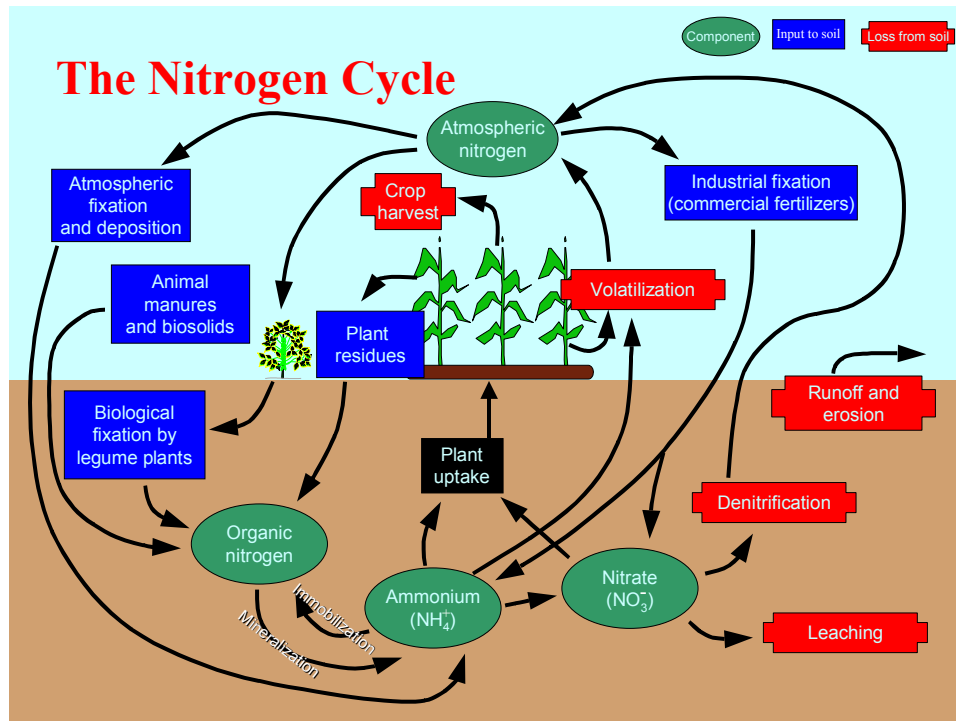
**What** are the important variables affecting plant-available nitrogen? Nitrogen for crops can come from four sources. One of these is the residual inorganic pool of ammonium ( $\text{NH}_4^+$ ) and nitrate ( $\text{NO}_3^-$ ) that can, under some conditions, accumulate in soil from mineralization or from previous nitrogen fertilizer application. The second source is di-nitrogen gas ( $\text{N}_2$ ) fixed from the atmosphere by symbiotic bacteria living in nodules on roots of legumes. Mineralization of nitrogen from soil organic matter and crop residue is the third major source. The fourth source, and the one most readily managed, is nitrogen fertilizer. Ability to control the rate and timing of nitrogen fertilizer provides an opportunity to compensate for an inadequate supply from the other sources and to synchronize availability of nitrogen with crop demand. Often, one or more of these sources of nitrogen can be eliminated from consideration based upon the specific crop and the environment in which it is grown. When a non-leguminous plant like wheat is grown, for example,  $\text{N}_2$  fixation is an insignificant source of nitrogen. The relative importance of the remaining sources of nitrogen changes as the production of wheat shifts from one climatically dictated cropping system to another. For example, in wheat-fallow rotations practiced under low rainfall conditions, residual inorganic nitrogen (primarily  $\text{NO}_3^-$ ) often supplies as much or more nitrogen to the crop than does current-season mineralization. In contrast, residual nitrate ( $\text{NO}_3^-$ ) is leached out of Willamette Valley soils during late fall and early winter and provides much less nitrogen to wheat than does nitrogen mineralized from crop residue and soil organic matter. This is why soil tests for inorganic nitrogen are not very useful in predicting nitrogen fertilizer needs for winter wheat in the Willamette Valley.

**How** much nitrogen can be supplied by mineralization? Predicting the amount of nitrogen supplied by mineralization is complicated by the fact that winter wheat is grown in a number of rotations and may follow a variety of crops in the Willamette Valley. The quantity and nature of the residue from the previous crop, and how it was handled, all influence how much nitrogen becomes available.

Roger Kjelgren, former graduate student, measured nitrogen uptake by unfertilized winter wheat ranging from 24 lb. per acre where the previous crop was wheat to 118 lb. per acre where the previous crop was crimson clover. Another student, Kevin Sebastian, found that nitrogen uptake ranged from 96 lb. per acre after clover to 162 lb. per acre after pea. In a recent three-year study, graduate student Maqsood Qureshi showed that a Woodburn silt loam supplied wheat with an average of 42 lb. nitrogen per acre per year following crimson clover as compared to 20 lb. per acre per year following spring oats. Besides illustrating the impact of previous crop, these results suggest that mineralization can meet from less than 10 % to more than 60 % of a winter wheat crop's requirement for nitrogen. The challenge is to accurately predict how much nitrogen will be mineralized and available to wheat in any given

field. Dost Baloch, recent Ph.D. graduate in Crop Science, made a significant contribution to nitrogen availability prediction by calibrating a mineralizable nitrogen soil test. Mineralizable nitrogen was measured by incubating 0 to 12 inch soil samples collected after mid-December for 7 days at 104° F under anaerobic (oxygen limited) conditions and then analyzing for  $\text{NH}_4^+$ . Field calibration showed that plant-available nitrogen increased about 5 lb. per acre for each 1-ppm increase in mineralizable nitrogen over the range of 12 to 28 ppm. Thus, a field testing 25 ppm would be expected to provide 50 lb. per acre more nitrogen to a wheat crop than would a field testing 15 ppm. Efforts are underway to encourage the use of this new soil test by Willamette Valley wheat producers. Could you increase profits by using this new soil test to refine nitrogen fertilizer management?

Accompanying Figure.



Christensen, N.W. 1999. Have you thought about nitrogen mineralization lately? Oregon Wheat, Vol. 50, No. 1:10-11.