Nitrogen in Soil Applications

Being a constituent of many plant cell components, including amino acids and nucleic acids, nitrogen is the mineral element that plants require in greatest amount.

In the soil applications, whether the nitrogen source is an inorganic or organic fertilizer, plant roots take them up only in the form of NH_4^+ or NO_3^-. For soil applications, ammonia, ammonium compounds, urea and nitrate compounds are the commercially available sources of NH_4^+ and NO_3^-.

The uptake of NH_4^+ or NO_3^- by plant roots varies considerably with the plants, the stage of the growth and the soil conditions. Due to the nature of charge on these ionic species, their retention in the soil structure for them to be available for the plant roots depends on the cationic exchange capacity (CEC) of the soil.

When the CEC of soil is high, for example clayey loam, cationic NH_4^+ is the preferred species over the anionic NO_3^- to adsorb into the soil structure. The negatively charged NO_3^- remains as free ions, and with the irrigation water they drain out to the lower level of the soil cross section. In such case, for the early stage of the plant growth with their high root level in the soil structure the NO_3^- species may drain through to a lower level and miss the root network, leaving the roots deprived of nitrogen source. For the later stages of the plant growth, when the root zone is at much lower level, though NO_3^- would drain through the soil structure but during the drainage it encounters the root network and is able to provide a source of nitrogen for the plant. It is due to this reason, in many crops, nitrogen in the form of NO_3^- is considered a good source of nitrogen at the later stage of its growth when the roots are well set at the lower level in the soil cross section.

Due to its cationic nature, NH_4^+ species remain in the soil structure being associated in the adsorbed form at the negatively charged surfaces. Adsorption is much greater in the soil with high CEC values. However, even in the case of sandy soil with low CEC value, NH_4^+ adsorbs at the surfaces of the sandy particles as counter ions and it provides a ready source of nitrogen for the plant roots to be taken up. In sandy soil, when the irrigation water drains freely, the use of nitrogen source in the form of NH_4^+ is advantageous over the NO_3^- form.

Regardless of the source of NH_4^+, due to nitrification process in the soil, it ultimately converts into NO_3^-. Under certain soil conditions, NO_3^- could be lost through biological denitrification to gaseous N_2 and N_2O. This occurs particularly in the soil low in oxygen and has an available energy source, e.g. carbonaceous material. Thus, in a soil with high organic matter, excess moisture and layered fine textures, there is increased denitrification and, therefore, loss of nitrogen to the environment. Loss of nitrogen can, however, be reduced by improving the permeability of the soil structure through flocculation of soil particles.

Two of the major nitrogen based fertilizers on the market are N-Cal®, a urea-calcium chloride blend, and Ca $(NO_3)_2$. They are mostly used as the calcium source. While N-Cal® introduces nitrogen to the soil in the form of NH_4^+, nitrogen available from Ca $(NO_3)_2$ is in the form of NO_3^-. Due to the presence of calcium in the N-Cal® composition, the usual loss of nitrogen that takes place due to ammonia volatilization when urea is applied is minimized. N-Cal®, therefore, is considered to be a preferred fertilizer in most soil structures. Its superiority over Ca $(NO_3)_2$ as a source of nitrogen becomes still more pronounced in the sandy soil.