Influence of Nitrogen Cycling on Sugarbeet Nutrition

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Numerous environmental factors influence yield and quality of sugarbeets. Crop management practices should be designed to produce optimum conditions which favor the production and storage of sucrose. Nitrogen (N) nutrition is an important factor in sugarbeet production and can be effectively managed. A thorough understanding of N cycling in the soil-plant-atmosphere system is essential when attempting to maximize sucrose production.

Plants obtain N in the mineral forms NO₃⁻ (nitrate) and NH₄⁺ (ammonium). Nitrate accounts for the majority of absorbed N.

Plant available NO₃⁻ arises from four primary sources: (1) Atmospheric dinitrogen (N₂) "fixed" by free-living soil microorganisms (nonsymbiotic). The "fixed" N is either assimilated into cellular constituents or released into the soil as NH₄⁺. (2) Atmospheric N₂ "fixed" by bacteria associated with leguminous plant roots (symbiotic). The genus Rhizobium infects alfalfa roots providing the plant with NH₄⁺ while using photosynthates produced by the plant for energy. Nitrogen "fixed" in this manner is assimilated into plant cellular constituents or excreted into the soil. The N found in plant and microbial cells is associated with carbon and is therefore considered an organic form. As plants and microbes decay, organic N forms are converted to mineral or inorganic forms of N. Nitrogen mineralization is a three step, microbially mediated process. Reactions convert proteins to amines and amino acids. The amino acids are converted to ammonia which the ammonia converted to nitrite then nitrate. The abundance of N for the crop following alfalfa is attributed to gains in soil N from nodule excretions and mineralization of organic N from plowed down alfalfa crowns and roots. (3) Release of mineral N forms from animal manures. (4) Fertilizer applied either to the previous or current crop. This provides considerable nitrate nitrogen for crop demands.

Nitrogen losses from the system can occur by: (1) leaching of NO₃⁻ through the soil profile, (2) denitrification, or the gaseous N loss under waterlogged conditions, (3) immobilization, or the tie-up of mineral N in organic N forms. Immobilization typically occurs when residues such as wheat straw high in carbon (C), are soil incorporated. Soil microorganisms respond to the added C and begin to multiply in order to use the new energy source. Because the residue is high in C compared to N, the organisms must utilize mineral N from the surrounding soil to build cellular proteins. Although this mineral N is "immobilized" in microbial bodies, it will eventually become plant available.

Three components must be quantified to successfully supply sugarbeet N requirements: 1) residual soil mineral N to rooting depth by soil sampling and analyses, 2) N mineralized during the growing season, 3) amount of non-legume residue plowed down.

Soil samples that are representative of the field to be fertilized are essential in determining N fertilizer requirements. Southern Idaho soils under warm, moist conditions (those conditions provided during sugarbeet production) can mineralize up to 150 pounds of N per acre. This value may vary depending on soil type.

Grain straw or corn stover may supply 3 to 4 tons of non-legume residue per acre. Fifteen pounds of N per ton of non-legume straw or stover are required per acre (maximum of 50 pounds per acre) to prevent immobilization.

Quantification of residual soil N (by soil test), N mineralization during the growing season, and non-legume residue plowed down provide sufficient information for accurate N fertilizer recommendations. Consult University of Idaho CIS No. 271 for specific recommendations. Crop management strategies for the production of high beet tonnage with maximum sugar percentage must account for potential N gains or losses from the soil-plant-atmosphere system.

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