Chapter One

AN OVERVIEW OF NITROGEN METABOLISM IN HIGHER PLANTS

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NITROGEN SOURCES

The predominant sources of nitrogen for higher plants are NH₄⁺, NO₃⁻ and N₂. In most forests, where soils are acidic and low in nitrogen, NH₄⁺ is the major nitrogen source. In agricultural soils, NO₃⁻ is the primary source of nitrogen for plant growth and development, even though NH₄⁺ or urea fertilizers may have been applied. Soil microorganisms, under normal conditions, oxidize the NH₄⁺ or urea-N to NO₃⁻ by the process of nitrification. In this review, the metabolism of nitrogen obtained by higher plants from NH₄⁺, NO₃⁻ or N₂ will be discussed.

J. E. Poulton et al. (eds.), Plant Nitrogen Metabolism
AMMONIUM METABOLISM

The availability of nitrification inhibitors, like nitrapyrin, has increased interest in \( \text{NH}_4^+ \) uptake and metabolism. Plants adapted to acid soils, i.e., many tree species, or those adapted to low soil redox potentials such as rice, have a preference for \( \text{NH}_4^+ \). The uptake and metabolism of \( \text{NH}_4^+ \) may change plant metabolism in several ways; it can (1) alter uptake of other cations like Mg\(^{2+}\), (2) increase root respiration, (3) lower soluble carbohydrate in roots, (4) stimulate root exudation, and (5) increase putrescine synthesis. The growth and development of plants grown under \( \text{NH}_4^+ \) nutrition may be quite different from plants grown with \( \text{NO}_3^- \) nutrition.

Ammonium nutrition causes a reduction in root elongation that results in short, thick roots with increased lateral root formation. This stimulation of lateral root formation may be responsible for the increase in cytokinin concentration in the xylem sap of apple root stocks and in the number of new spurs produced with \( \text{NH}_4^+ \) nutrition versus \( \text{NO}_3^- \) nutrition. By judicious use of \( \text{NH}_4^+ \) and nitrification inhibitors, economic advantages might be gained in the growth and development of certain agronomic or horticultural plants as compared to the more common \( \text{NO}_3^- \) nutrition.

There are several enzymes potentially capable of incorporating ammonia into organic forms as amino acids and amides. These include alanine dehydrogenase, aspartate dehydrogenase, asparagine synthetase (AS), glutamate dehydrogenase (GDH) and glutamine synthetase (GS) (Table 1); of these, only the last three have been reported in higher plants. Although most higher plants absorb very little \( \text{NH}_4^+ \) through their root systems, they are equipped with and use enzymes designed for \( \text{NH}_4^+ \) assimilation. All forms of nitrogen used by the plant are ultimately reduced to \( \text{NH}_4^+ \) and incorporated into organic combination. In addition, large quantities of \( \text{NH}_4^+ \) are assimilated daily through the pathway called the photorespiratory nitrogen cycle (Fig. 1). In the intensive nitrogen metabolism involved in photorespiration, two molecules of glyoxylate are converted to glycine. One molecule of glycine is decarboxylated, deaminated and the remaining methylene carbon is