Soil Quality Indicators

Potentially Mineralizable Nitrogen (PMN)

PMN can be defined as the fraction of organic nitrogen converted to plant available (or mineral) forms under specific conditions of temperature, moisture, aeration, and time. Determining levels of PMN can provide an estimate of available N in the soil.

PMN originates mainly from microbial biomass and plant and animal tissues—the main source of the organic nitrogen pool. It represents the fraction of nitrogen easily decomposable by soil microorganisms and is considered an indirect measure of nitrogen availability during the crop-growing season (if measured during that period).

While anaerobic N mineralization potential may be a good indicator of the potential for soil to deliver N, it does not necessarily reflect microbial biomass N levels. It was suggested that the ratio of N mineralized to total organic nitrogen N could serve as a sensitive indicator of differences in soil organic matter (SOM).

Factors Affecting

Inherent — Levels of PMN may be greatest in humid climates and lower in drier climates because humid climates usually enhance biomass production. Clay soils have the capacity to physically protect organic matter and organic nitrogen and, thus, associated PMN from degradation by microorganisms. During the soil incubation to measure PMN, soil clay particles can attract and temporarily retain ammonium on cation-exchange complexes. The depth to bedrock affects soil hydrologic properties (e.g., fluctuation of water table and subsequent soil hydromorphy, causing excess or low moisture amounts), which in turn determine the chemical end products of N mineralization, namely ammonium or nitrate. Low areas (topographic depressions) of a field tend to accumulate more organic matter and total N, and probably available N and PMN, than higher areas.

Dynamic — Soil properties and soil management practices that affect organic matter and organic N dynamics will ultimately affect available N and PMN levels. Continuous cultivation of lands without the replenishment of external organic matter depletes the land's organic matter and nitrogen reserve and the related available PMN. Conversely, repetitive additions of farm manure or crop residues (as under no-till or cover crops) usually increase the levels of available N and probably PMN (as shown in Figure 1); no-till significantly increases PMN levels compared to the plow and fertilizer addition. Soils with stable aggregates protect soil organic matter and associated available N from microbial degradation compared to soils with unstable aggregates. Small aggregates in soil reportedly contain a larger proportion of readily mineralizable organic N; therefore, a greater amount of PMN may be obtained in soils with small aggregates than in those with larger aggregates. Accumulation and mineralization of N also depend upon the C:N ratio of amendment materials added to the soil.

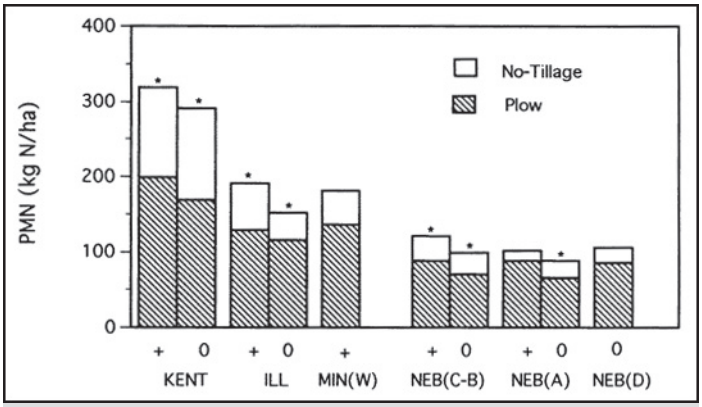

Figure 1. PMN levels in the 0-7 cm soil layer as influenced by tillage management (+ = NH_4NO_3, 0 = no fertilizer, white block = no tillage, dashed block = plow, and * = significant difference at $p < 0.05$) (Doran, 1987).

Relationship to Soil Function

As a readily available fraction of total N, PMN is an important potential source of N for crop growth and yield, especially in synthetic N-fertilizer-free agricultural operations (e.g., organic farming). PMN can be a source of available N for microorganisms and indirectly enhances microbial growth and activities, including C and N cycling. In well drained soils, PMN is made available to plants and microorganisms, mostly in the form of nitrate, through aerobic mineralization. In poorly drained soils (such as rice fields), PMN is made available, in the form of ammonium, through anaerobic mineralization.

Problems with Poor Activity

Soils naturally low in organic matter or depleted by poor management will have low PMN content. In the absence of live vegetation, a high amount of available N delivered by the PMN pool can build up and become a potential source of nitrate contamination for ground water. An excess of nitrate from the PMN pool can be lost in the atmosphere as gaseous nitrogen products during subsequent very wet seasons or under heavy irrigation (*many of those products, like nitrous oxide, are greenhouse gases*).

Improving Management

The following practices increase available N in soils:

- Application of organic residues and farm manure to increase microbial biomass and organic nitrogen
- Addition of N fertilizer at recommended rates and optimal times
- Adoption of conservation practices, such as no-till (see Figure 1) and cover crops
- Erosion control to reduce the transport of available N by sediment to streams and other bodies of water

Figure 1 shows that PMN levels were greatest in the surface layer (depth of 0 to 7.5 cm) of soil under no-till management compared with conventional tillage. The results were more dramatic in the humid climate compared with the dry. Biomass and PMN levels were greatest below a depth of 7.5 cm of plowed soil. PMN levels were primarily associated with microbial biomass carbon (MBC) and total N distribution. Figure 2 shows PMN obtained in anaerobic incubation; high levels of PMN were obtained in soil amended with crop residues (rice residues).

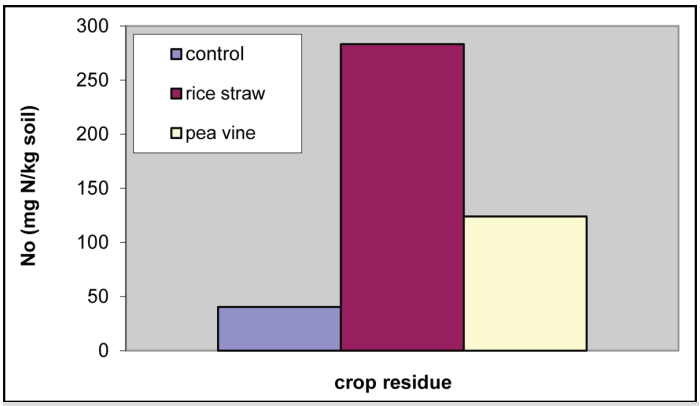

Figure 2. PMN (No) in flooded soils amended with rice straw and pea vine (Islam et al., 1998).

Measuring PMN

- Anaerobic method (Waring and Bremner, 1964): PMN is estimated in the laboratory on soils by measuring ammonium N produced in soil incubated under anaerobic conditions for 1 week.
- Aerobic method (Stanford and Smith, 1972): PMN is estimated in the laboratory on soil by measuring ammonium N and nitrate N produced in soil incubated under aerobic conditions for 30 days. Cumulative N is used in a mathematical model to compute PMN.
- Other methods have been suggested, but they are not discussed in this document.

References

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