N MINERALIZATION AS AFFECTED BY CONTRASTING SOIL DRAINAGE, TILLAGE, AND AGE OF GRASS SEED CROP

M A. Nelson and S.M. Griffith

Introduction

The most limiting nutrient in western Oregon grass seed crops is nitrogen (N). Grass seed crops derive N from two major sources: grower applied N fertilizer and mineralized organic N in the soil. For years, the major focus of grass seed crop fertility research has been to optimize N fertilizer timing and rate, with little reference given to background N gains and losses from the soil-N cycling processes. To optimize site-specific crop fertility, one cannot use N fertilizer recommendations based on N rate trails alone. One must be able to reasonably determine the amount of N derived or lost from different N processes. To do this, an understanding of existing field conditions combined with the knowledge of how these conditions influence mineralization processes is needed for western Oregon. The focus of this research was to understand soil N inputs from mineralization processes and their relationship to crop N uptake and plant development for fine fescue grown on a well-drained soil and tall fescue on a moderately-drained soil.

Background Information

The contribution of mineralized N to grass seed crops can vary based on soil drainage class, tillage events, soil moisture, and temperature. This complexity could explain the varied response that grass seed growers show with different applied N rates under Willamette Valley conditions. Under some circumstances, little or no applied N is required for maximum seed yield, while under other situations crops may require applied N fertilizer amounts that exceed extension service recommendations. These differences have not been explained.

Soil-N mineralization is rarely measured in agricultural fields. Estimates of N mineralization when measured are often based on laboratory soil incubations under constant controlled conditions and have little relevance to environmental conditions in the field. Thus, laboratory mineralization analyses do not estimate when mineralization occurs and how it is related to crop-N demand. In contrast, methods for measuring soil-N mineralization directly in the field have been used in forest and natural ecosystems. The most commonly used method for in-field measurements relies on the incubation of soil cores within sealed polyethylene bags buried in the soil. In the absence of plant uptake and leaching of N from these buried bags, the difference in inorganic N concentrations between soil at the beginning and end of the incubation period is a direct measure of net N mineralization. The bags are assumed to reflect conditions in the surrounding soil. This methodology also allows for studies to be made in soil under variable climatic and management conditions throughout the year.

Hypotheses

We hypothesized that establishment year perennial grass seed crops using no-tillage will have net N mineralization rates lower than those found in tilled fields and that microbial biomass N will increase. Increased soil drainage will also enhance mineralization. Tillage incorporates crop residues and aerates the soil making it more conducive to soil microbial degradation and N mineralization, hence greater N loss. Following the establishment year, perennial grass seed production systems will return to a more N-conserving system that will reduced annual N mineralization losses and enhanced sequestration of N and C. With the absence of tillage during grass seed crop establishment, soil organic matter degradation will be slowed, less NO_3^- leached, greater C and N sequestrated, and more N will be available longer in the crop root zone.

Experimental

USDA-ARS research plots are located in Willamette Valley at two locations with contrasting soil drainage classifications and different grass species being grown that were established in 1992 as part of the long-term integrated agricultural systems project (www.pws.ars.usda.gov/nfsprc/steinerj.htm). One site is located on a diversified grass seed-cereal grain family farm located in the Silverton Hills region of eastern Marion County. The second site is located at the Oregon State University Hyslop Research Farm in Benton County.

The Marion County site has a Nekia-Jory Association soil, a well-drained, silty clay loam over clay and the Benton County site is a Woodburn soil series with poor to moderately drained silty loam over fine sandy loam. The Willamette Valley has a Maritime climate with hot, dry summers and cool, wet winters. The mean annual precipitation is 1114 mm with 60-70% occurring between October to April. The annual mean air temperature is 12 CE. The continuous grass treatment plots were planted in the spring to a three-year cycle with 'Bridgeport' fine fescue (Marion County) or 'Hounddog' tall fescue (Benton County). All no-till treatments were initially established in 1992.

The in-field buried bag method was used to quantify N mineralization using twenty-four incubations from September 1999 to June 2001, with an average duration of 26 days used to quantify N mineralization. An intact soil core, 5 cm diameter by 15 cm deep, was removed, sealed within a zip-seal polyethylene bag, and replaced in its original position in the ground. The bag was covered with loose soil and litter to reduce exposure. A second and third core was taken 10 to 15 cm away from the first to determine initial inorganic nitrate-N and ammonium-N.

One additional soil core per incubation soil core was taken and placed in polyethylene bags and transported to the laboratory for analyses of baseline soil properties Day-0). Two separate sub-samples from the cores were extracted with 100 ml of 0.5 M K_2SO_4, shaken for 30 minutes on a rotary shaker at 350 rpm, and filtered through a #1 Whatman filter. The filtrate was frozen for later analysis of nitrate-N, ammonium-N, and organic carbon. Nitrate and ammonium was analyzed using a Lachat Quick Chem 4200 analyzer. Additional sub-samples of soil were taken for determination of soil moisture by gravimetric methods and soil biomass (data not reported). Soil biomass C was determined using the chloroform fumigation extraction method with 48 h fumigation period (data not reported). Total organic carbon was quantified with high temperature catalytic combustion and infrared detection on a Rosemount/Dohrman DC-190 (data not reported). Soil pH was measured using a glass electrode (1:2, soil: water ratio). Soil organic matter was estimated using a loss on ignition method (data not reported).

To estimate mineralized N available to the crop, zero N plots and fertilized plots were established and temporal plant biomass and N uptake data was measured (Nelson and Griffith, 2001). These data were compared with temporal soil N and mineralization process data to determine relationships between soil N availability and plant uptake. Plant biomass was collected throughout the season at least monthly. Above and below ground plant samples were collected from three 30 x 30 cm randomly selected areas in each replicated treatment. Plant morphological development indicators were recorded throughout the season. All temporal biologic and physical data was expressed on a accumulated growing degree scale (T_{sum} scale). Plant biomass samples were forced-air oven dried at 70EC, and weighed. Plant material was ground using a Tecator Cyclotec 1093 sample mill and analyzed for total N using a Perkin Elmer 2400 Series II CHNS/O analyzer.

Preliminary Findings of Net Mineralization/Immobilization

Soil Drainage Effect

Net mineralization and immobilization (negative net mineralization rates indicate N immobilization) was greater for the well-drained Nekia-Jory soil with the fine fescue seed crop (Figure 1) compared to the moderately-drained Woodburn soil with tall fescue seed crop (Figure 2).

Tillage Effect

Conventional tillage resulted in greater net N mineralization and immobilization in the fall and spring compared to no till treatment. This was particularly pronounced for the Nekia-Jory soil (Figures 1 and 2).

Age of Stand

By the third year of fine fescue or tall fescue seed production, net immobilization was reduced (Figures 1 and 2).

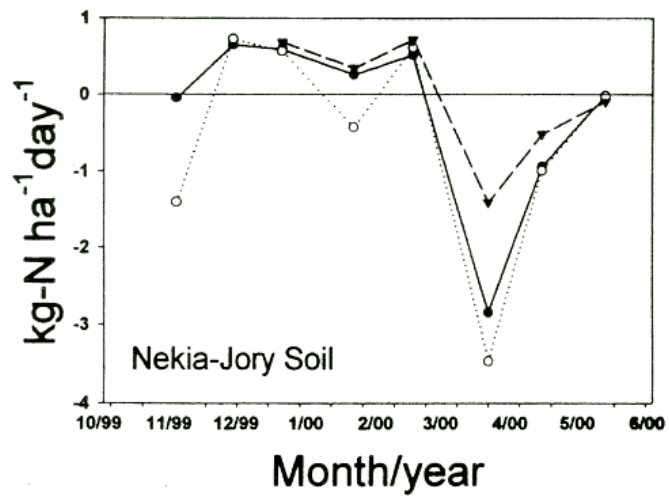

Figure 1. Temporal patterns of net N mineralization for fine fescue during the first seed-year no-till planted (closed circle), first seed-year tilled prior to planting (open circle), and third seed-year tilled prior (3 years previous) to planting (closed triangle). All crops were spring planted.

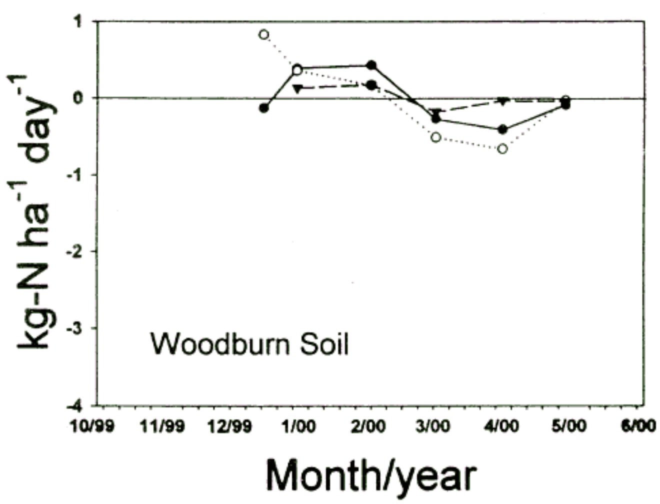

Figure 2. Temporal patterns of net N mineralization for tall fescue during the first seed-year no-till planted (closed circle), first seed-year tilled prior to planting (open circle), and third seed-year tilled prior (3 years previous) to planting (closed triangle). All crops were spring planted.

Related References

Eno, C.H. 1960. Nitrate production in the field by incubating the soil in polyethylene bags. Soil Sci. Amer. Proc. 24:277-279.

Gilliam, J.W. and G.D. Hoyt. 1987. Effects of conservation tillage on fate and transport of nitrogen. In: *Effects of Conservation Tillage on Groundwater Quality: Nitrates and Pesticides*, 217-240, eds. J.J. Logan et al. Chelsea, Mich.: Lewis Publishers, Inc.

Nelson, M.A. and S.M. Griffith. 2001. Tall and fine fescue: relationship between growing degree days, developmental stage, and nitrogen acquisition. In: *Seed Production Research*, W. Young, III (ed.), Oregon State University Extension and USDA-ARS, Corvallis, Oregon, pp __ - __.

Groffman, P.M. 1985. Nitrification and denitrification in conventional and no-tillage soils. Soil Sci. Soc. Am. J. 49: 329-334.