Legume Identity and Timing of Incorporation Effects on Soil Responses to Green Manure

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Introduction

Challenges to sustainable agriculture include optimizing nitrogen (N) availability, maintaining profitability by reducing input costs, such as synthetic N fertilizers, and minimizing the loss of nitrate-N. Production of a legume green manure in a crop sequence is a typical method used to reduce or eliminate the need for applying synthetic N fertilizer to succeeding crops. Legumes or legume/small grain mixtures are often used as green manures because of the symbiotic association of most legume species with N fixing *Rhizobium* bacteria. The dynamics of nitrogen (N) mineralization in the soil after legume incorporation are complex. To contribute adequate amounts of plant-available N to the subsequent crop, the incorporated green manures must decompose sufficiently and in synchrony with the N demand of crops such as corn.

In this study, oats (*Avena sativa* L.) were sown with red clover (*Trifolium pratense* L.), alfalfa (*Medicago sativa* L.), or alone. Oat residue and legumes were incorporated in the fall of the seeding year or the following spring, before corn (*Zea mays* L.) production. The objectives of this study were to 1) quantify the timing and extent of net N mineralization following oats/alfalfa, oats/red clover, and oats alone, and 2) determine the effect of fall or spring green manure incorporation on net N mineralized for a subsequent corn crop.

Materials and Methods

The experimental layout was a randomized complete block, split-plot design with four replicates. Whole-plot treatments comprised a factorial of three cropping sequences (oats/alfalfa-corn, oats/red clover-corn, and oats-corn) crossed with two manure incorporations (fall or spring preceding corn). The whole–plots (200 ft x 15 ft) were split into sub–plots (50 ft x 15 ft) that received a set of N fertilizer rates (0, 60, 120, 180 lbs N $acre^{-1}$) during the corn year and were evaluated for another part of this study. Soil samples analyzed for the mineralization study were taken from plots with no added N fertilizer.

Oat and legume species were planted in mid-April of 2000 and 2001, and oats were harvested for grain in late July. Fall incorporation (FI) was done in November of the seeding year and spring incorporation (SI) was done the following April with a moldboard plow. Corn was planted in early May of 2001 and 2002 at 32,000 seeds/acre in 30-inch rows.

Experiment I. Soil potentially mineralizable N was quantified on three dates in the corn production years: 1) April, before spring green manure incorporation, 2) June, pre-fertilizer application, and 3) October, post-harvest. Soils were aerobically incubated for 28 days at 86°F.

Experiment II. Net soil mineralization in the field was determined during the corn years from soils retained in the field in polyethylene bags for a period of 14 days. Net mineralized N (NMinN) was determined from the difference between the soil inorganic N (SIN) in the bagged sample (after 14 days) minus the baseline SIN measured at the initiation of the 14 day cycle. Eleven 14-day field incubations were analyzed over the growing season.

Results and Discussion

Experiment I. Potentially mineralizable N. Potentially mineralizable N was significantly greater (Year 1: P=0.0115; Year 2: P=0.0002) in the SI treatments than in the FI treatments in April (Figure 1). The primary differences were between the SI and FI oat/legume treatments. No significant main effects were observed for the subsequent sample dates in either year (data not shown). In both years, mineralized N from June soils ranged from 85 to 105 kg N ha^{-1}. All green manure treatments in the October samples mineralized over 100 kg N ha^{-1}, except for the FI oat treatment in Year 1 (89 kg N ha^{-1}). This indicated a strong potential for continued soil N mineralization under optimum conditions.

Experiment II. Cumulative net mineralized N. Temporal trends in cumulative NMinN for the FI (data not shown) and SI green manure treatments (Figure 2) were similar for both years. Cumulative NMinN in the SI oat/legume treatments were greater than in the oat treatment. The SI oat/red clover treatment was significantly greater (Year 1: P=0.05; Year 2: P=0.03) than the oat treatment by the end of the season (Figure 2).

The SI oat/red clover treatment had significantly greater amounts of incorporated biomass N than the oat treatment in both years (data not shown). In addition, the SI oat/legume treatments had C:N ratios less than 15:1, and the SI oat treatments were greater than 25:1 in both years. This indicated that the SI oat/legume biomass might have been more readily decomposed.

The timing of green manure incorporation had no significant effect on the NMinN in the field. Averaged over tillage treatments, each green manure treatment reached over 50% of the season total of NMinN by July and 75% by August in both years (Table 1). In both years, the SI oat/legume treatments showed greater net N mineralization across the season (Figure 2).

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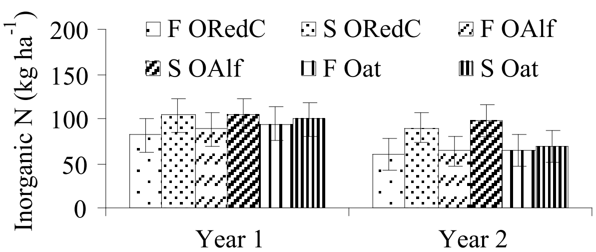

Figure 1. April incubations – Net mineralizable N. (Vertical bars represent lsd $_{0.05}$)

Table 1. Cumulative percent of total net mineralized N.

Year 1	29 May	26 Jun	24 Jul	21 Aug	19 Sep
O/RedC	33.6	54.8	75.9	89.4	98.4
O/Alfalfa	33.1	52.7	75.5	89.3	97.1
Oat	24.1	57.0	81.5	93.7	98.3
Year 2	**3 May**	**6 Jun**	**5 Jul**	**1 Aug**	**1 Sep**
O/RedC	0.4	22.3	63.2	80.4	100.0
O/Alfalfa	7.6	31.5	62.0	80.3	100.0
Oat	2.6	20.5	62.5	75.8	95.7

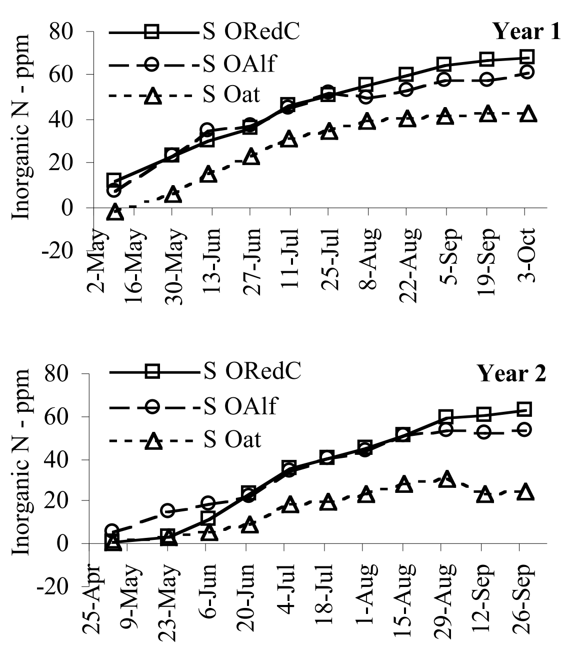

Figure 2. Cumulative field net mineralized N.