Optimizing the Use of Legume Green Manures in Rotations that Include Corn

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Introduction

Farmers interested in reducing or eliminating the use of synthetic nitrogen (N) fertilizers from their cropping systems often use the N_2 fixing capabilities of legume green manure crops in their rotations. The dynamics of N mineralization in the soil after a legume crop are complex and are influenced by many environmental factors. For optimum performance, N-supplying legume crops must decompose sufficiently, and at the appropriate time, to contribute adequate amounts of plant-available N to a subsequent N-consuming crop, such as corn. The objectives of this project were to 1) determine the N fertilizer replacement value of two legumes, alfalfa (*Medicago sativa* L.) and red clover (*Trifolium pratense* L.), when they were intercropped with oats (*Avena sativa* L.) and incorporated into the soil in the fall or in the spring preceding a corn (*Zea mays* L.) crop; and 2) quantify the net N mineralization potential of soil amended with alfalfa and red clover residues during the corn phase of a two-year cropping sequence.

Materials and Methods

Field studies were conducted on two 1.65-acre fields at the Northeast Research and Demonstration Farm, Nashua, Iowa. The first field study was planted with oats and legumes in spring 2000, and the second field study began in 2001. The experiments used a randomized complete block, split-plot design with four replicates. Whole-plot treatments comprised a factorial of three cropping sequences (alfalfa/oat–corn, red clover/oat–corn, and oat alone–corn) crossed with two tillage times (fall or spring plowing preceding corn). The six treatments were replicated four times in the two fields. The whole-plots (200 ft × 15 ft) were divided into sub-plots (50 ft × 15 ft) that received a set of N fertilizer rates to determine the fertilizer replacement value (FRV) of the legume crops for a subsequent corn crop. Urea was applied in early June with a Gandy spreader at rates of 0, 60, 120, or 180 lbs N/acre and incorporated immediately after application. In the second year for each field study, corn was planted at 32,000 seeds/acre in 30-in. rows.

Oats and the legume species were planted in mid-April of 2000 and 2001, and oats were harvested for grain in late July of each year. Fall and spring incorporation of the oat residues and legumes was done with a moldboard plow. Corn was planted in early May 2001 and 2002, and a broadleaf herbicide was used for post-emergent weed control.

In addition to corn yield, plant and soil measurements made during each growing season included corn population density, corn ear leaf nutrient concentrations, SPAD® readings, and cornstalk nitrate concentration. Three central plot rows were harvested for grain yield data in early October 2001 and 2002. The FRV of the legumes were calculated using curves describing corn grain yield responses to different rates of N fertilizer.

This project also included potential nitrogen mineralization analyses, through in-situ incubation of soil samples under field conditions and lab incubation of soil samples to quantify potential mineralization of nitrogen under optimum conditions. These data have not yet been fully analyzed and will be discussed in a later report.

Results and Discussion

2001. First year yield results indicated that the FRV for spring-incorporated legumes was greater than for fall incorporation (Table 1, Figures 1 and 2). Ear leaf tissue samples, taken in late July and analyzed for N concentration showed a significantly lower value in the oat alone treatments compared with the legume treatments; all treatments were below the lower range (2.90%) of sufficiency. Corn stalk nitrate analyses indicated optimum nitrate levels for the legume treatments with 120 lbs N/acre. The timing of legume incorporation had no significant effect on yields in 2001, with an average of 175 bushels/acre for both fall and spring.

2002. Second year yield results indicated that the FRV for fall- incorporated red clover was greater than for spring incorporation (Table 2, Figures 3 and 4). Although the timing of tillage significantly lowered corn population density, plant density was not a significant factor in the reduced yield for the spring treatments. Corn ear leaf and stalk samples collected for inorganic N analyses have not yet been processed.

We are now in the process of interpreting FRV and yield differences observed in 2001 and 2002 in the context of field and lab N mineralization rates, so that we may better understand and predict how tillage timing and crop sequence affect soil conditions and crop performance.

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Table 1. 2001 fertilizer replacement values.

Tillage	Legume	FRV (lbs N/acre)
Spring	Red clover	101
Fall	Red clover	37
Spring	Alfalfa	70
Fall	Alfalfa	45

Table 2. 2002 fertilizer replacement values.

Tillage	Legume	FRV (lbs N/acre)
Spring	Red clover	82
Fall	Red clover	127
Spring	Alfalfa	88
Fall	Alfalfa	77

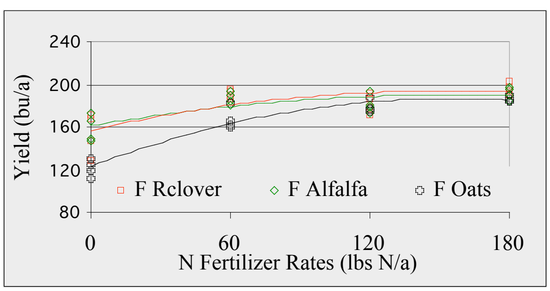

Figure 1. 2001 corn yields with fall incorporation.

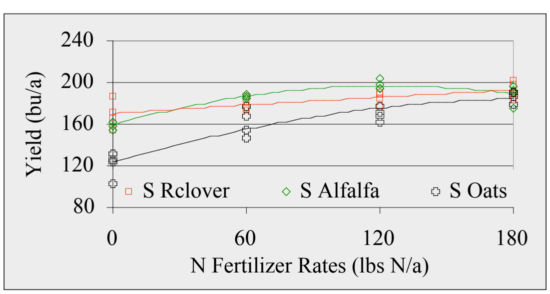

Figure 2. 2001 corn yields with spring incorporation.

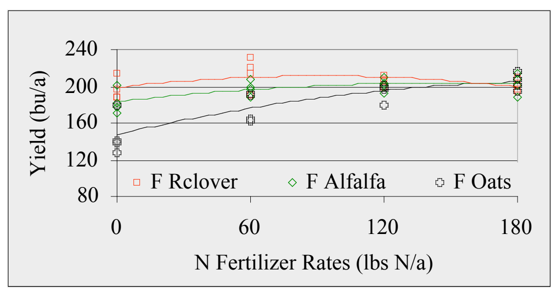

Figure 3. 2002 corn yields with fall incorporation.

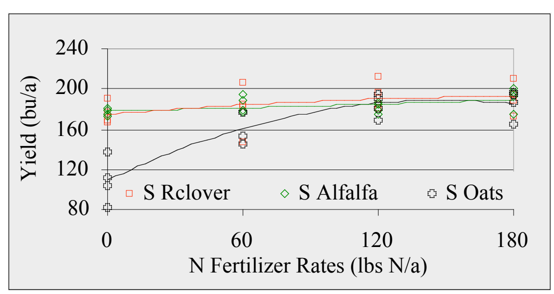

Figure 4. 2002 corn yields with spring incorporation.