Nitrogen Uptake by Corn in a Winter Legume Conservation-Tillage System

D.W. Reeves* and J.T. Touchton

Introduction

The use of winter annual legumes in conservation-tillage systems can reduce soil erosion, improve soil productivity, increase infiltration of rainfall, conserve soil water, and furnish N to subsequent summer grain crops. Estimates of N contributed to subsequent crops generally range from 50 to 100 lb/acre (Hargrove, 1986; Neely et al., 1987; Tyler et al.. 1987; Ebelhar et al., 1984, Touchton et al., 1982).

Research with corn *(Zea mays* L.) grown in conventional-tillage systems has generally shown the benefit of delaying application of the majority of N fertilizer until 4 to 6 weeks after planting (June et al., 1972; Bigeriego et al., 1979; Welch et al.. 1971). Although delayed application of N has also been shown to increase N efficiency of corn in no-till systems (Fox et al., 1986; Frye et al., 1981), nitrogen dynamics in no-till legume systems complicate timing of fertilizer N applications. The delay in growth because of low soil temperatures associated with no-till systems in the Corn Belt is not appreciable in the South. Thus, demand for N by corn in no-till systems in the South occurs earlier in relation to planting date. This fact is exacerbated by the relatively slow release of N from winter legumes in conservation-tillage systems. Wilson and Hargrove (1986). using a mesh-bag technique. reported that 63% of N remained in crimson clover *(Trifolium incarnatum* L.) residue 4 weeks after plating bags in the field, as opposed to 40% remaining in bags under conventional tillage. Groffman et al. (1987), in a comparison of conventional and no-tillage systems, reported that tillage affected timing of N availability more than the total amount of available N. Huntington et al. (1985) reported that the majority of N mineralized from decomposing residues of hairy vetch *Vicia villosa* Roth) in a no-till system became available to corn after silking.

Synchronization of fixed-N release. fertilizer-N application time, and subsequent crop demand for N could improve N use efficiency of summer crops planted in winter legume conservation-tillage systems. This study was initiated to determine: I) the N contribution from a winter annual legume to corn grown in a conservation-tillage system 2) the N uptake profile of corn grown in this type system, and 3) the optimum N rate and time of application for corn grown in this system on a coastal plain soil.

Materials and Methods

This field study was conducted for 3 years (1986-1988) on a Norfolk sandy loam (fine, loamy, siliceous, thermic Typic Paleudult) located in east-central Alabama. The soil is highly compactible, and the site has a well-developed tillage pan. The site was disked, field cultivated and seeded with crimson clover in mid-October of 1985, 1986, and 1987. At midbloom every year, clover was killed with gramoxone. A 'Brown-Harden Ro-Till' in row-subsoiler with unit planters was used to plant 'Pioneer 3320' corn in 30-inch rows 7-10 days after gramoxone application each year. Planting dates were 18 April, 5 May, and 29 April in 1986. 1987 ,and 1988, respectively. A starter fertilizer consisting of 120 lb/acre potassium-magnesium sulfate, 45 lb/acre triple superphosphate, 14 lb/acre zinc sulfate. and 8.75 lb/acre 'Solubor' was banded over the row. Plots were 4 rows wide and 35 ft long. Corn was thinned to 24.000 plants/acre 3 weeks after emergence.

The experimental design was a randomized complete block of 4 replications. Treatments consisted of a factorial arrangement of N fertilizer rates and application time. Nitrogen as ammonium nitrate, was broadcast at rates of 30.60, or 120 lb/acre. Zero-N checks were also included in both clover and rye *(Secale cereale* L.) check plots. Application times were at planting. or 3, 6 or 9 weeks later. In addition, split applications (1/3 at planting and the remainder 6 weeks later) of 60 and 120 lb N/acre were included. The test was not managed as irrigated corn, but if it did not rain within 2 days of N application, 3/4 inch of irrigation water was applied to move N into the soil.

Root and forage samples for dry matter and N determination were collected from clover and rye at time of gramoxone application. Corn whole plant samples were taken for dry weight and N concentration at 3 week intervals throughout the season until black layer. Stand counts were recorded periodically for calculation of N uptake. The middle 2 rows of each plot were harvested and weights were adjusted to 15.5% moisture for grain yield determination.

Results

Dry matter and N content of cover crops at burndown are listed in Table 1. Nitrogen content of clove and rye ranged from 99 to 156, and from 28 to 52 lb/acre, respectively. The percent of total N accumulated by cover crops found in screened root samples varied from 12.1 to 25.6% for clover, and from 9.7 to 15.6% in rye.

Table 1. Dry matter production and N content of cover corps at burndown, 7-10 days prior to planting corn.

Cover Crop	Dry Matter 1986	1987	1988	N. Content 1986	1987	1988
	-----	-----	lb/acre	-----	-----	-----
Clover	3904	5895	5479	99	156	123
Rye	2063	3906	2007	32	52	28

*USDA-ARS. National Soil Dynamics Laboratory. and Department of Agronomy and Soils. Alabama Agricultural Experiment Station, Auburn University. Alabama. respectively.

Corn Dry Matter Accumulation

In 1986, there was an extreme drought for the 12-week period following planting. Neither N rate nor timing of N application affected dry matter accumulation. The only treatment differences were between any treatment with supplemental N and 0-N checks in the rye and clover. Total dry matter accumulation at black layer averaged 14288 lb/acre for treatments with N fertilizer applied, 12055 lb/acre for 0-N plots in clover, and 7851 lb/acre for the rye check ($LSD_{0.10}$ = 1595 lb/acre).

In 1987, corn was planted late and rainfall distribution during the 5 week period centered around tasseling and silking was favorable. Both rate and time of N application significantly affected dry matter accumulation. Nitrogen rate had no effect on dry matter accumulation until later than 6 weeks after planting. By the end of the season, dry matter averaged 9329, 11374, 12967, and 14684 lb/acre for 0-N clover check, and 30.60, and 120 lb/acre N rates, respectively ($LSD_{0.10}$ = 1144 lb/acre). Rye check plots averaged only 3302 lb/acre dry matter 15 weeks after planting.

Applying N later than 3 weeks after planting generally reduced dry matter production in 1987. Dry matter produced 15 weeks after planting averaged 13671, 13573, 12320, and 12466 lb/acre ($LSD_{0.10}$ = 1320 lb/acre) for N applied at planting, or 3, 6, or 9 weeks later, respectively. Split applications were less effective for dry matter production than applying N at planting or 3 weeks later. In 1988, rainfall was generally favorable, with an excellent distribution during grain fill. As in 1986, there was no response to N rate nor application time, other than differences between 0-N checks and any treatment where N fertilizer was applied. Total dry matter accumulation at black layer averaged 14152 lb/acre for treatments with N fertilizer applied, 12257 lb/acre for 0-N plots in clover, and 3256 lb/acre for rye check plots ($LSD_{0.10}$ = 1504 lb/acre).

Nitrogen Uptake

In 1986, time of N application had no effect on N uptake. Nitrogen uptake by corn through the season followed similar patterns regardless of the time of application

In 1987 and 1988, N application timing produced significant differences in N uptake, however, differences were transitory and solely due to the treatment variable, i.e., withholding N fertilizer applications in relation to days from planting. For both years, by the end of the season, there was no difference in N uptake due to timing of N application. In 1988, however, there was a trend ($P<0.16$) for greater N uptake when fertilizer N was applied at planting. Total N uptake in 1988 averaged 219, 169, 159, and 167 lb/acre when N was applied at planting, or 3, 6 or 9 weeks later, respectively. Split applications did not result in greater N uptake in any year.

The I20 lb/acre N rate resulted in greater N uptake than the 30 or 60 lb/acre N rates in 1986 (Fig. 1). Nitrogen uptake in 0-N clover plots was 47 lb/acre greater than in rye plots. The apparent amount of fertilizer N recovered (N content from fertilized plots - N content from 0-N clover plots) was similar for the 30 and 60 lb/acre N rates, averaging 20 Ibiacre. For the 120 lb/acre N rate, the apparent fertilizer N recovered was 48 lb/acre. In 1987, the difference in N uptake patterns among N rates was evident 6 weeks after planting (Fig. l). By the end of the season, N uptake in 0-N clover plots was 60 lb/acre greater than in rye plots. Apparent N recovery of fertilizer averaged 94%, 97%, and 83% for the 30, 60, and 120 lb/acre N rates, respectively. Nitrogen uptake patterns in 1988 were generally similar to those in 1986. (Fig. l). The 120 lb/acre N rate resulted in greater N uptake 6 weeks after planting, however, by the end of the season there was little difference among total N uptake regardless of N rate. Total N uptake for the 30 and 60 lb/acre N rates were similar and averaged 39 Ibiacre more than that in 0-N clover plots. Corn fertilized with 120 lb/acre N took up 56 lb/acre more N than corn in 0-N clover plots.

Grain Yield

In 1986, time of N application did not affect grain yield (Table 2). However, at the 120 lb/acre N rate, split application resulted in the highest yields (133 bu/acre). Yields, at the 120 lb/acre N rate, were equivalent for N applied at planting, or 3, 6, or 9 weeks later (107 bu/acre averaged). In 1987 and 1988, delaying N application until 9 weeks after

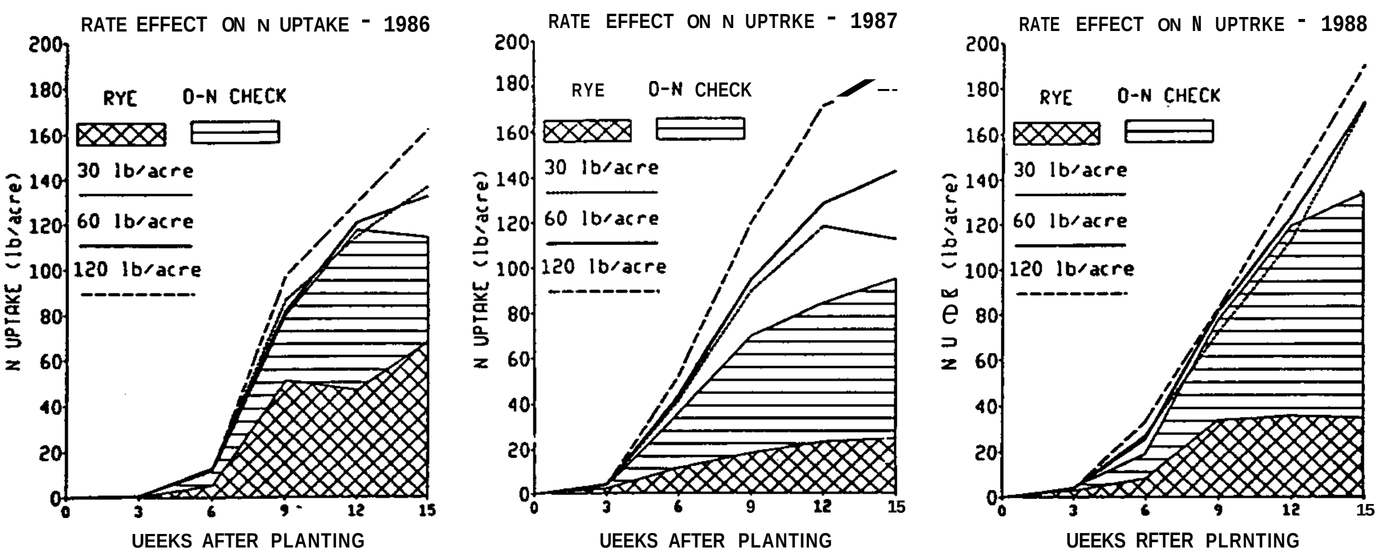

Figure 1. Nitrogen uptake of corn grown in a winter legume conservation-tillage system as affected by fertilizer N rate.

Table 2. Effect of N application time, averaged over N rate, on grain Yield of corn grown in a conservation-tillage system with crimson clover.

	N Application Time, wk after planting				
	0	3	6	9	$LSD_{0.10}$
	bu/acre				
1986	104	105	108	109	13.4
1987	107	112	106	81	7.6
1988	124	121	119	111	11.4

Table 3. Effect of N rate, averaged over application time, on grain yield of corn grown in a conservation-tillage system with crimson clover.

	N, lb/acre					
	0	30	60	120	Rye check	$LSD_{0.10}$
	bu/acre					
1986	77	92	92	107	2	11.7
1987	68	92	103	108	2	6.6
1988	106	116	123	117	22	9.8(NS)

planting decreased yield (Table 2). There was no benefit from split applications either of these years.

In 1986, maximum yield was obtained with 120 lb/acre N (Table 3). In 1987, a year of good rainfall distribution, optimum yield was obtained with only 60 lb/acre despite the fact that corn fertilized with 120 lb N/acre took up an additional 41 lb N/acre over that fertilized with 60 lb N/acre. In 1988, the greatest response to N rate came with the first 30 lb/acre applied (Table 3).

Conclusions

In 2 of 3 years, neither N rate nor application time affected total dry matter accumulation of corn grown in a winter legume conservation-tillage system. In I year, when corn was planted late and rainfall distribution was excellent, dry matter production was proportional to N rate, and applying N later than 3 weeks after planting reduced dry matter production. Application time did not affect total N uptake, but did effect grain yield. Applying N later than 6 weeks after planting reduced grain yield in 2 or 3 years. Delaying N application beyond 6 weeks had a negative effect on grain yield except in a year of extreme drought. Grain yield responded to 120, 60, and 30 lb N/acre, respectively, in successive years. Results from this study indicate that for nonirrigated corn grown in a winter legume conservation-tillage system on sandy coastal plain soils; the optimum management practice for conservation of N, energy, time and labor would be to apply 60 lb N/acre at planting.

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