Functions of Legume Cover Crops in No-Till and Conventional Till Corn Production

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Legumes are important in crop production due to their capability of fixing atmospheric nitrogen. In addition to supplying biologically fixed N to the corn, they add organic matter, affect the supply of available water and plant nutrients, improve the physical properties of the soil, and provide erosion control (3).

In Kentucky, research conducted from 1977 through 1983 (1, 3) showed that winter annual legumes could be grown as cover crops in a continuous no-till corn system. Hairy vetch resulted in the greatest yields of corn grain, because it produced more dry matter, thus more mulch, and higher nitrogen content than the other cover crops. The plots used for the above experiment were split in 1984, and one-half of each plot was conventionally tilled. The objectives of this were to (a) determine the effects of legume cover crops in both conventional till and no-till systems, (b) compare the effects of continuous no-till with that of periodic conventional tillage following several years of no-till, and (c) evaluate the system under higher rates of fertilizer N than was used previously.

MATERIAL AND METHODS

The experiment was conducted at Lexington, Kentucky on a Maury soil (fine-silty, mixed, mesic, Typic Paleudalf). The plots were established in 1976 and maintained through 1983 under a system of continuous no-till corn with annual legumes as cover crops (1). In 1984 the plots were split into conventional till and no-till treatments. The winter cover crops were overseeded in mid-September 1983 into the standing no-till corn. Cover treatments were hairy vetch alone, hairy vetch mixed with annual ryegrass, big flower vetch, rye, and corn residue alone. The annual ryegrass winter-killed leaving a pure stand of hairy vetch, therefore, results from that treatment were omitted from this paper. Each of the cover treatments were combined with 0, 85 and 170 kg/ha N from NH_4NO_3 fertilizer, broadcasted at corn planting time. Cover crop samples were tak n on four 0.25-m^2 areas from each plot before planting and N fertilization. Dry matter yield and N content were determined from those samples. On 18 May 1984, corn was planted at a rate of 50,000 plants per ha using a no-till corn planter. Following planting, the plots were sprayed with 1.17 L/ha paraquat mixed with 3.36 kg/ha cyanazine. Soil samples were taken at monthly intervals from depths of 0 to 7.5 cm and 7.5 to 15 cm and analyzed for NH_4 and NO_3 and total soil N. Soil samples for moisture determination were taken weekly at the 0- to 15-cm depth in each plot. Daily maximum and minimum soil temperatures were measured at 5-cm depth in the rows and between the rows for the first 30 days after corn planting. Corn grain was harvested in early October 1984.

RESULTS AND DISCUSSION

Legumes as Nitrogen Source

Hairy vetch produced more dry matter and had greater N content than big flower vetch or rye at any N fertilizer level (Table 1). With no N fertilizer, hairy vetch contained 117 kg/ha N compared to 47 and 27 for big flower vetch and rye, respectively. With 170 kg/ha N, hairy vetch produced 131 kg/ha N compared to 46 and 56, respectively, for big flower vetch and rye. Big flower vetch contained significantly higher N percentage than rye, but produced the lowest amount of dry matter, and that low dry matter production was reflected in the unusually low level of N content of the big flower vetch at the 170-kg/ha N treatment.

Table 1. Dry matter production and N content of cover crops (top growth), 1904.

	Fertilizer N rates 1977-83 (kg/ha)					
	0 (0)†		50 (85)		100 (170)	
Cover	DM‡	N	DM	N	DM	N
Rye	1.7	27	3.0	45	3.5	56
Big flower vetch	1.5	47	2.2	75	1.6	46
Hairy vetch	3.0	117	3.1	119	3.3	131

† Numbers in parentheses are 1984 fertilizer N rates.
‡ DM = dry matter, Mg/ha; N = N content, kg/ha.

At planting and before N fertilizer was applied, total N of the 0- to 7.5-cm depth of soil was consistently higher under no-till than conventional till for all cover treatments (Table 2). The ratios of total N of no-till to that of conventional till ranged from 1.15 to 1.30. In the 7.5- to 15-cm depth, however, total N tended to be higher under conventional till, and the ratios were from 0.88 to 1.07. This resulted from inverting the surface 15 cm of soil by moldboard plowing, so that the higher organic matter content was in the 7.5- to 15-cm depth.

Table 2. Effects of tillage, cover treatment, and N fertilizer rate on total soil N before N fertilization, 1984.

	Fertilizer N rates 1977-83 (kg/ha)			
	0 (0)+		100 (170)	
Cover	CT‡	NT	CT	NT
	---Total soil N, %---			
	0- to 7.5-cm depth			
Corn residue	0.165	0.190	0.189	0.202
Rye	0.164	0.196	0.161	0.210
Hairy vetch	0.174	0.212	0.169	0.217
	- - m depth			
Corn residue	0.166	0.160	0.153	0.164
Rye	0.157	0.156	0.168	0.158
Hairy vetch	0.182	0.160	0.179	0.161

+ Numbers in parenthases are 1984 fertilizer N rates.

‡ CT = conventional tillage (plowed one week before sampling); NT = no-tillage.

At planting, prefertilization values of available N (KCl extractable NH_4^+ plus NO_3^-) under no-till tended to be higher in the 0- to 7.5-cm depth and lower in the 7.5- to 15-cm depth than under conventional till, although differences were small (Fig. 1). Regardless of fertilizer treatments, hairy vetch resulted in more available N in the at 0- to 7.5-cm depth for both no-till and conventional till. Soil samples taken June 28 (one month after N fertilization) showed that available N increased significantly both in no-till and conventional till, at both sampling depths and with and without N fertilizer; the increase was much greater with conventional till, than with no-till. With conventiona till, and no N fertilizer, available N under hairy vetch increased by 99% over the month before, while the increase was only 13% with no-till. This indicates that a substantial amount of organic N was mineralized during the first month of the corn season and more mineralization occurred with conventional till, than no-till. This is consistent with results reported by Smith and Rice (5).

If we assume that 50% of the N of the top growth was mineralized during the corn growing season, the hairy vetch would have provided about 60 to 65 kg/ha N from top growth alone (50% of the N values from Table 1). If we assume further that the ratio of N in top growth to N in roots was 4:1, an additional 15 to 16 kg/ha N would have been supplied by the roots assuming also 50% minealization from the roots. This is slightly less than the 90 to

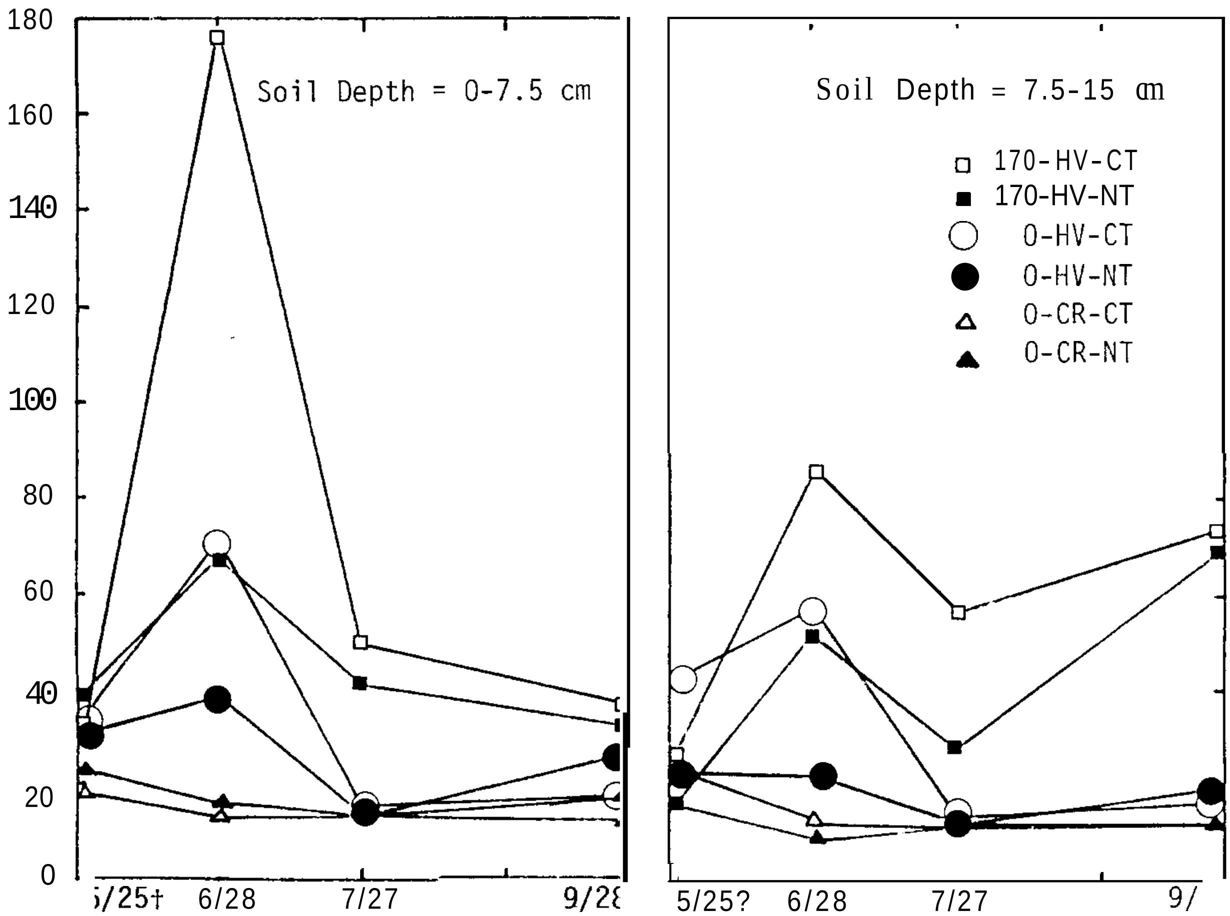

Fig. 1. Available soil nitrogen (NH_4^+ + NO_3^-) of no-tillage and conventional tillage, 1984. (HV = hairy vetch? CR = corn residue; 170 and 0 = kg/ha of N fertilizer; †Before N fertilizer applied).

100 kg/ha/yr N estimated by Ebelhar et al. (1) from grain yields and based on fertilizer N equivalent, but it does not take into account mineralization of stored soil organic N. We presently do not have a reliable estimate of that.

<u>Legumes as Mulch</u>

The mulch from killed winter cover crops affects soil temperature, soil moisture, and soil erosion. Maximum and minimum soil temperatures were measured daily at 5-cm depth during the first month after planting the corn. The average maximum soil temperatures, measured both in row and between row, were consistently lower under no-till than conventional till. However, no-till maximum soil temperatures under corn residue, rye, and hairy vetch were 1.9, 1.8, and 3.6 C, respectively, higher when measured in the row slits than when measured between the rows and only 0.7, 0.3 and 1.2 C lower than in the row of the respective cover treatments with conventional tillage. Apparently, the microclimate of the slit of the corn row in no-till is fairly similar to conventional till. The average minimum soil temperatures under no-till were generally not significantly different than under conventional till.

The mulch cover with no-till was effective in conserving soil water, resulting in more available water than with conventional till. Hairy vetch, rye, and corn residue treatments with no-till averaged 3.6, 3.1, and 1.8%, respectively, higher in gravimetric soil moisture content than with conventional till during the first 7 weeks of the season.

Effect on Corn Grain Yield

Corn grain yield without N fertilizer was greater with the legume cover crops than with rye or corn residue, both in no-till and conventional till (Table 3). Yield with hairy vetch was greater than with big flower vetch. The familiar relationship between corn yield, tillage system, and N fertilizer rate discussed by Phillips et al. (4) was apparent in these data. Corn yield was greater with conventional till than no-till where no fertilizer N was applied, but with N fertilizer, no-till corn tended to outyield conventional till corn. The greater yield under conventional tillage with no N fertilizer was thought to be due to the greater N mineralization indicated by Fig. 1. The tendency for greater yield under no-till with N fertilizer applied was probably because soil water was higher under no-till, resulting in more efficient use of the fertilizer N by the corn plants.

Table 3. Effects of cover treatment, N fertilizer rate, and tillage on corn grain yield, 1984.

	Fertilizer N rates, 1984 (kg/ha)					
	0		85		170	
Cover	CT+	NT	CT	NT	CT	NT
	Yield of corn grain‡ (Mg/ha)					
Corn residue	4.9	3.1	5.9	5.5	6.2	6.2
Rye	5.1	3.3	6.3	6.4	6.8	7.0
Big flower vetch	6.0	4.0	7.0	7.6	5.6	5.7
Hairy vetch	6.8	6.0	6.3	6.8	7.2	7.6

+ CT = conventional tillage; NT = no-tillage.

‡ Based on 15.5% moisture.

Corn appeared to respond well to N fertilizer up to 170 kg/ha N with all tillage and cover treatments except big flower vetch at 170 kg/ha N (Table 3). The decrease in corn yield between 85 and 170 kg/ha fertilizer N on the big flower vetch plots has been shown to be a result of differential erosion of the soil of the experimental area (2).

CONCLUSIONS

When the plots of an 8-year old continuous no-till corn experiment were split into no-till and conventional till, the first year's data showed:

1) With no N fertilization, no-till resulted in lower corn grain yields than conventional till, however, with the 170 kg/ha N rate, grain yields with no-till were generally higher. In both tillage systems, hairy vetch had the greatest influence on corn grain yields compared to other cover treatments.

2) Because of inversion the plow layer, total soil N under conventional till was less than no-till in the 0- to 7.5-cm depth, but was greater than no-till in the 7.5- to 15-cm depth. Available N (NH_4^+ and NO_3^-) was generally greater under conventional till. This was attributed to greater N mineralization.

3) The maximum soil temperature at 5-cm depth measured in the row under no-till with corn residue, rye, and hairy vetch cover, respectively, were 1.9, 1.8 and 3.6 C higher than between rows and only 0.7, 0.3 and 1.2 C lower than where measured in the row of conventional till.

4) Soil water content in the 0- to 15-cm depth under corn residue, rye, and hairy vetch was 1.80, 3.1 and 3.68, respectively, higher with no-till than with conventional till.

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