Time of Plowing, Nitrogen Rate, and Cover Crop for Corn on Chalmers Silt Loam[1]

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Abstract

Fall plowing was compared with spring plowing with and without rye (*Secale cereale*) as a winter cover crop for continuous corn (*Zea mays* L.). In this split-plot type experiment with four randomized replications, subplot treatments were two annual rates of nitrogen (N) fertilizer, 168 kg/ha and 1344 kg/ha. Under relatively dry March and April conditions the higher rate of N drastically reduced the population of rye plants, probably due to the release of free ammonia with surface application of large amounts of urea. Both fall plowing and spring plowing with a winter rye crop turned under before corn planting produced more corn grain (probability $< .20$) than spring plowing with no rye cover. Grain yields of the 1344 kg/ha rate of N were significantly (probability $< .05$) greater than those of the 168 kg/ha rate of N both for the five year period and in two of the individual years. Even though limestone was applied both in 1970 and in 1971 where needed according to soil pH and lime requirement tests, by September, 1974, the soil pH of the higher rate of N was significantly (probability $< .01$) lower by 0.7 pH unit than that of the lower rate of N.

Introduction

Joffe (5) emphasizes the constancy of organic matter of cultivated soils in a particular soil forming region. His belief is that the value of green manure crops when incorporated into soils, should be examined with reference to soil forming processes. Cover crops seeded in the fall are often used as green manure crops in Indiana. Morgan and Hannah (6) considered rye (*Secale cereale*) as a vehicle to store fertility nutrients, in Nixon sandy loam in New Jersey, for the cash crop, sweet corn (*Zea mays* L. rugosa). They found that fertilization of rye as a means of storing nutrients for use of the succeeding cash crop was economically doubtful. Benoit, Willits, and Hannah (2) also used rye as a cover crop on Nixon sandy loam in New Jersey. They found that with rye, soil capillary porosity was increased and that bulk density was decreased. Roots and stubble alone or the whole plant plowed under benefited the soil most. They did not report cash crop yields. Uhland (8) reported unpublished data from Rutgers University showing that a rye cover crop increased sweet corn yields 18% and tomato (*Lycopersicum esculantum* Mill) yields 3% in an 11-year study. Beaty and Giddens (1) found that removing the green manure crop before planting reduced corn (*Zea mays* L.) yields.

The purposes of this research were to compare (a) fall and spring plowing, (b) spring plowing without cover crop with spring plowing with a rye cover crop, and (c) one normal rate and one very high rate of nitrogen (N) for growing commercial dent corn (*Zea mays* L. indentata (Sturt) Bailey) on Chalmers silt loam.

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Methods and Procedure

This experiment was located on Chalmers silt loam soil, a Typic Argiaquoll, located near Lafayette, Indiana. Old farm tile of undefined extent and effectiveness partially drained this depressional area which had been cropped to corn and soybeans for several years. After spring plowing in 1969, a corn crop was grown on all plots in 1969. The plow layer had an organic matter content of 2.36% and a cation exchange capacity of 18.8 milliequivalents/100 g by the methods of Jackson (4). Bray No. 1 phosphorus (P) was 44 ppm. Available potassium (K) was 150 ppm by the method used in the Purdue Soil Testing Laboratory (Five g of soil are shaken with 15 ml of neutral normal ammonium acetate for two minutes, filtered, and 2 ml of the extract diluted to 10 ml. K is read by atomic absorption). Soil pH of the plow horizon was 6.8. Ten or more soil cores 2 cm in diameter were taken to a depth of 15 cm from each plot, air dried, ground, and passed through an approximately 2 mm (screen door wire) screen, and mixed for soil pH determinations using a 1:1 soil-water ratio (estimated by weight), stirring, allowing to sit 20 minutes, stirring again, and then testing with a glass electrode pH meter.

The experimental design was split plot with four randomized replications. Main plot treatments were (a) fall plowing after the previous corn crop was harvested, (b) spring plowing, and (c) spring plowing of a rye cover crop planted in the previous fall after the corn crop was harvested. Fall plowing was done between October 30 and November 24 when weather and soil permitted, starting in 1969. Rye was seeded between September 29 and November 12 after the corn grain was harvested. Balbo rye was seeded broadcast at the rate of 168 kg/ha disked into the soil. The first rye crop was seeded in the fall of 1969. Spring plowing was done between April 10 and May 10 after the N had been applied during the period 1970-1974. Spring plowing was done on May 23 in 1969. Depth of plowing was approximately 20 cm.

Main plot treatments were 18.3 m long and 6.1 m or eight corn rows wide. All plots received uniform P and K fertilizer applications over the six-year period (1969-1974) that the experiment was conducted. They were applied in late spring prior to spring plowing. These fertilizers were 1780 kg/ha of 0-11-21 (% of N-P-K) in 1969, 1120 kg/ha of 0-11-21 in 1970, 383 kg/ha of 0-5.7-32 in 1971, and 448 kg/ha of 0-11-21 in 1972.

Each main plot was divided laterally in the middle into two subplots 9.15 m long, one receiving 168 kg/ha of N from 45% N urea annually and the other receiving 1344 kg/ha of N annually. These treatments were initiated in the spring of 1969. The urea was applied broadcast between April 11 and April 25 which was as soon as it could be done on bare soil or on growing rye. Agricultural ground limestone was applied broadcast as required in both 1970 and in 1971. Rates of limestone applied were based upon soil pH and the pH buffer test of Shoemaker, McLean, and Pratt (7).

Aldrin granules were incorporated into the soil by disking to control northern corn root worm (*Diabrotica longicornis* (Say)) and for southern corn root worm (*Diabrotica undecumpunctata howardi* Barber) control.

Corn planting date was between May 4 and June 8 each year. Commercial hybrid seed corn was planted. Seeding was in 75 cm rows, and the rate was as low as 64,215 seeds/ha in one year and as high as 69,888 seeds/ha in another year. Hybrids planted were DeKalb XL-45 in 1969, Pioneer 3516 in 1970, and Pioneer 3369A in the last four years.

Different combination of Aatrex, Bladex, Lasso, and cultivation in different years were used for weed control. Diazinon granules were broadcast into the whorls of corn each year to control European corn borer (*Ostrinia nubilatus* Hubner) when plants were between 75 and 125 cm maximum in leaf height.

Grain harvest areas were in the two center rows in each subplot, and their length was 4.0 m in most years. Corn ears were hand harvested. Moisture percentages in the grain and Brunson's tables (3) were used to convert ear corn weights to yields of shelled corn with 15.5% moisture.

Statistical methods used were those explained by Steel and Torrie (9).

Results and Discussion

Crop growth and soil moisture

In 1971 it was visually observed that fall plowed plots dried off on the surface more slowly after a rain than did spring plowed, possibly because they contained more moisture accumulated in winter. In 1972 (May 28) and in later years it was visually observed that the soil dried out sooner after a rain on plots where rye had been turned under. This could have been the result of larger soil pores and more water stable soil aggregates where rye stubble, roots, and tops were decomposing.

Another observation made in 1971 showed the difficulties likely to be encountered with the higher rate of N, 1344 kg/ha. The population of rye plants on this treatment was noticeably reduced. There was only a trace of precipitation during the last two weeks in March and only 18 mm in April of 1971, when this difficulty was observed. This type of damage was not observed to be of major importance in other years when precipitation in spring was more abundant. A possible explanation for the damaging effects of surface application of high rates of urea under relatively dry conditions is that gaseous ammonia is released. In other years rye on the 1344 kg/ha rate of N plots was taller and greener than on the 168 kg/ha rate.

Grain yields

Average yields of the spring plowing treatment with no rye cover were about 400 kg/ha less than those of both fall plowing and spring plowing with rye cover (Table 1). These differences were statistically significant at 4 to 1 odds (probably $< .20$). What appears to be a statistically significant interaction between time of plowing with or without cover crop and rates of N, is not—largely due to wide variation among replications.

TABLE 1. *Influence of time of plowing and cover crop on the grain yield of continuous corn 1970-1974.*

Time of plowing	Cover Crop	Grain yield in kg/ha		
		N applied annually, kg/ha		
		168	1344	Mean
Fall	none	8,902	9,954	9,428
Spring	none	8,256	9,835	9,044
Spring	rye	8,663	10,303	9,483
Least Significant Difference .20 level				312

Yields for the five-year period, 1970-1974, with the 1344 kg/ha rate of N were 1,423 kg/ha higher than those of the 168 kg/ha rate of N (Table 2). This difference was statistically significant at the 1% level of probability. The average grain yields in both 1970 and in 1974 were lower than those of other years. The 1970 August rainfall of 27.4 mm was 55.1 mm below normal for that month, and the 1974 July rainfall of 27.2 mm was 55.1 mm below normal. Deficient rainfall in July and/or August in the Midwestern states has been shown to reduce corn yields.

TABLE 2. *Influence of annual rate of nitrogen (N) and year upon the average yield of continuous corn 1970-1974.*

N applied annually kg/ha	Grain yield in kg/ha					
	1970	1971	1972	1973	1974	Mean
168	7,715	10,813	9,052	7,547	7,908	8,607
1,344	8,081	10,968	11,232	10,874	8,997	10,030
Sig. Diff. .05	ns**	ns	yes	yes	ns	yes

**ns = not significant

Soil pH

Even though the individual plots were tested for soil pH in both 1970 and in 1971 and limed at rates determined by the Shoemaker, McLean, and Pratt buffer test (7), by September, 1974, there was a highly significant (probability $< .01$) difference of 0.7 pH unit between the soil pH's of the 0-15 cm plow horizon of the two rates of N (Table 3). This difference in soil pH indicates that rapid increases in soil acidity can be expected when very high rates of urea fertilizer are used, even though corrective limestone has been used previously. At the 30-46 cm depth organic matter was about .80% less than in the surface 0-15 cm, but not related to treatment. At the 47-53 cm depth soil pH was lower than at the 30-46 cm depth, but there was no meaningful difference in organic matter percentages between these two depths.

TABLE 3. *Influence of depth in the soil and rate of nitrogen (N) application (1969-1974) upon soil pH and upon soil organic matter composition.*

Depth in soil cm	Annual rate of N kg/ha	Soil pH 9/16/74	Organic matter % 9/16/74
0-15	168	6.7*	2.35
0-15	1344	6.0*	2.36
30-46	168	6.4	1.55
30-46	1344	6.4	1.42
47-53	168	5.7	1.19
47-53	1344	5.8	1.43

* These two values are significantly different at the 1% level.

Conclusions

1. Both fall plowing and spring plowing with a rye winter cover crop resulted in higher (probability of 4 to 1 or greater) average yields of continuous corn on Chalmers silt loam soil than did spring plowing with no cover crop.

2. The higher annual rate of N fertilizer, 1344 kg/ha, produced higher (probability of 19 to 1 or greater) average yields of corn grain than did the lower rate, 168 kg/ha. The higher rate of N fertilizer resulted in a lower soil pH at the end of the experiment even though corrective limestone was applied three years earlier.

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