TILLAGE EFFECTS ON N MINERALIZATION AND LOSSES OF WINTER APPLIED MANURE

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ABSTRACT

A better understanding is needed of how conservation practices affect the concentration of soil N resulting from winter application of manure. This study was conducted to evaluate the effects of manure applications on the mineralization and concentration of N during the winter. The experiment was established in fields that were previously under conventional and conservation tillage with and without manure application. Dairy composted manure was applied annually in the fall prior to planting of a winter cover crop. The quantification of N released from composted manure and the amount of N uptake by plant tissues of the cover crop during winter months was determined. The concentration of N was higher in the conventional tillage plots at the beginning of the study and quickly diminished throughout the growing season. The conservation tillage plots with manure retained the most N compared to the other treatments. This treatment also had the highest plant biomass compared to the other treatments, indicating much more was retained in the plant tissues. These results show use conservation tillage in conjunction with cover crops when applying manure in winter months could potentially minimize the amount of N lost.

INTRODUCTION

Winter application of manure has been a common practice for many years; however, recent environmental concerns have led many researchers to question this practice. There has even been action taken to address the potential environmental affects of manure nutrient loss from agricultural lands. The Alabama Natural Resource Conservation Service (NRCS) has adopted new nutrient management standards (NRCS Code 590), which effectively ban the application of animal manures in North Alabama during winter months (Torbert et al. 2005). Hence, increasing pressure on farmers to provide sufficient storage for manure generated during winter months. Therefore, research is needed to better evaluate alternative management strategies.

Research has been reported regarding effects that winter manure application has on nutrient loss due to surface runoff, thereby affecting water quality (Young and Holt, 1977; Converse et al., 1976; Witzel et al., 1969; Hensler et al., 1970). Others have reported that NO_3-N leaching from manure is increased compared with fertilizer N applied at equivalent N rates (Roth and Fox, 1990; Jemison and Fox, 1994). This increase was attributed to late fall or early spring N mineralization producing soil inorganic N during periods when there is no plant N uptake (Stoddard et al., 2005). Conservation tillage practices such as no-tillage, which enhances water infiltration, could potentially create situations where NO_3-N leaching is likely (Stoddard et al., 2005). Earlier studies have shown both higher and lower concentrations of NO_3-N in leachate under no-tillage as compared to conventional tillage systems (McMahon and Thomas, 1976;

Tyler and Thomas, 1977; Angle et al., 1993). However, most of these studies have been carried out in the Midwestern and Northeastern Regions of the U. S. and were conducted without the use of winter cover crops. Therefore, there is a need to evaluate the effects of nutrient loss from manure application during winter months in the Southeast in order to better understand how conservation tillage practices combined with winter cover crops affects N loss.

MATERIALS AND METHODS

This study is a component of a larger farm system experiment (Terra et al., 2006), which was established on a site that had a long-term history of row cropping; mostly cotton (*Gossypium hirsutum* L.), under conventional tillage (moldboard or chisel plowing) for 30 years prior to the establishment of plots in 2001. Soils at this site are mostly fine and fine-loamy, siliceous, subactive, thermic Typic, Oxyaquic and Aquic Paleudults.

The study was a 2 x 2 factorial design with two soil management systems with and without annual application of composted dairy manure evaluated in a corn (*Zea Mays L.*)-cotton rotation. The four treatments consisted of: (1) conventional tillage system (CT); (2) conventional tillage system with manure (CTM); (3) conservation tillage system (NT); and (4) a conservation tillage with manure (NTM). The conventional tillage consisted of fall (chisel plowing/disking) and spring (cultivation and in-row sub-soiling) tillage operations; conventional tillage systems did not include winter cover crops. Winter weeds in the CT and CTM were not controlled. Conservation tillage systems consisted of no-tillage with non-inversion sub-soiling and a winter cover crop of black oats (*Avena strigosa* L.) and rye (*Secale cereale* L.) before cotton and winter cover crops crimson clover (*Trifolium incarnatum* L.) and white lupin (*Lupinus albus* L.) before corn.

Soil samples were taken prior to fall manure application. Six soil cores (1 inch dia., 8 inches deep) per plot were collected and composited. Samples were air-dried, ground and passed through a .08 inch (2 mm) sieve. Total C and N were determined by the DUMAS dry combustion method using a LECO CN 2000 analyzer (LECO Corp, St. Joseph, MI). Soil pH (1:1 soil/water) and CEC was determined by the Auburn Soil Testing Laboratory, and results are presented in Table 1.

Composted dairy manure was surfaced applied to the field at a rate of ~ 4 tons/A dry matter in the NTM and CTM plots prior to planting winter cover crops. The winter N mineralization study was initiated on October 22, 2004 (the day of manure application) and continued until the killing of the cover crop (March 12, 2005) prior to planting the summer crop. Soil samples were collected from the corn and cotton plots throughout the winter months (0, 3, 7, 14, 21, 28, 49, 70, 91,112, 133, 140 days after manure application), extracted using 2M KCl as described by Keeney and Nelson (1982), and measured for concentrations of NH_4 and NO_2 + NO_3 colorimetrically using the Bran-Luebbe automated laboratory equipment (Bran-Luebbe, Norderstedt, Germany). Soil water and moisture content was measured using a HOBO weather station (Onset Computer Corporation, Bourne, MA). Local weather data (rainfall and air temperature) were provided by a station located approximately 0.5 miles from the study site.

The study was a randomized complete block design (RCB) with three replications. Statistical analyses of data were performed using the mixed procedure of Statistical Analysis System (Littell et al., 1996). A significance level of $P<0.10$ was established *a priori*.

RESULTS AND DISCUSSION

At the beginning of the study, the concentration of inorganic N was higher for CT compared to that of NT (Figure 1). The higher values in the CT were not surprising since the conventional plots were subjected to tillage after harvest thereby pulverizing the soil and mixing the crop residue into the soil resulting in microbial breakdown of the residue. In conservation tillage, the crop residues are recycled back to the soil in a more stable form (slower decomposition rate) than those under conventional tillage. Plots receiving manure were higher in inorganic N although not significantly. On the day of manure application (day 0), the amount of inorganic N was higher in the CTM followed by the NTM due to the addition of manure N (Figure 2). However, it is important to note that although the CTM exhibited the highest inorganic N at the initiation of the experiment, the concentration rapidly diminished during the course of the winter season. This was likely due to leaching of inorganic N in the form of NO_3 and cover crop N uptake. Denitrification losses were probably not a significant contributor to N losses, since the sandy texture of the soil allowed most of the water to filter through instead of becoming saturated.

In general, the amount of inorganic N lost from all treatments followed changes in soil water content and temperature over time. Temperature seemed to have affected the concentration of N observed in this study. As temperature decreased, the concentration of N did not increase; this is probably because the temperature had dropped below the optimum for mineralization to occur (Figure 3). Also, at the beginning of the study, the concentration of N in the soil decreased after each rainfall event most likely due to leaching (Figure 4).

At the end of the study, the NTM contained significantly higher inorganic N compared to the other treatments (Figures 2 & 5). The amount of plant biomass collected from the NTM plots was significantly higher compared to the other treatments showing that the NTM treatment played an integral role by retaining N (Figure 6). Nitrogen uptake, although not significant probably due to the high variability of the data, was higher in the plant tissues under the NTM treatment (Figure 7) compared to the other treatments. This indicated that the utilization of a cover crop benefits the conservation tillage system by retaining more plant nutrients than the conventional tillage. These result are similar to Nyakatawa et al. (2002) who reported cover crop use during winter months can be used to scavenge residual N that would otherwise be lost to leaching, thereby alleviating groundwater pollution.

This study shows that agronomic practices that provide continuous plant cover should be utilized during winter months to minimize leaching of N associated with fallow soils under conventional tillage. Inorganic N (nitrate) tends to accumulate in fallow soil without plant cover or residue during winter months, thereby providing NO_3 that is susceptible to leaching (Mosier et al., 2002). Use of winter cover crops winter in conjunction with conservation tillage practices that maintain residue on the surface can play a major role in minimizing N loss due to leaching.

CONCLUSIONS

This study demonstrates that conservation practices can influence the loss of inorganic N from soil. Results suggest that winter manure application used in conjunction with conservation tillage practices that maintain surface residue and minimize soil disturbance could help reduce inorganic N losses compared to practices that leave the soil fallow. Also, some of the manure N that is retained can help increase the growth of cover crops in conservation tillage systems. This cover crop can be retained on the soil surface for the next growing season as residue and benefits the following crop. These finding show that there is a need for more research on the dynamics of

N leaching under different conservation tillage practices in conjunction with various cover crops in order to develop a N leaching Index of N loss when applying manure during winter months.

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Table 1. Selected soil properties.

Treatment	pH	CEC	Total C	Total N	C:N ratio
		cmol/kg	'--------- %	----------	
NTM	6.2	7.01	0.85	0.08	11.21
NT	5.5	6.02	0.54	0.56	9.72
CT	5.8	5.72	0.54	0.56	9.51
CTM	6.2	7.61	0.76	0.67	11.37

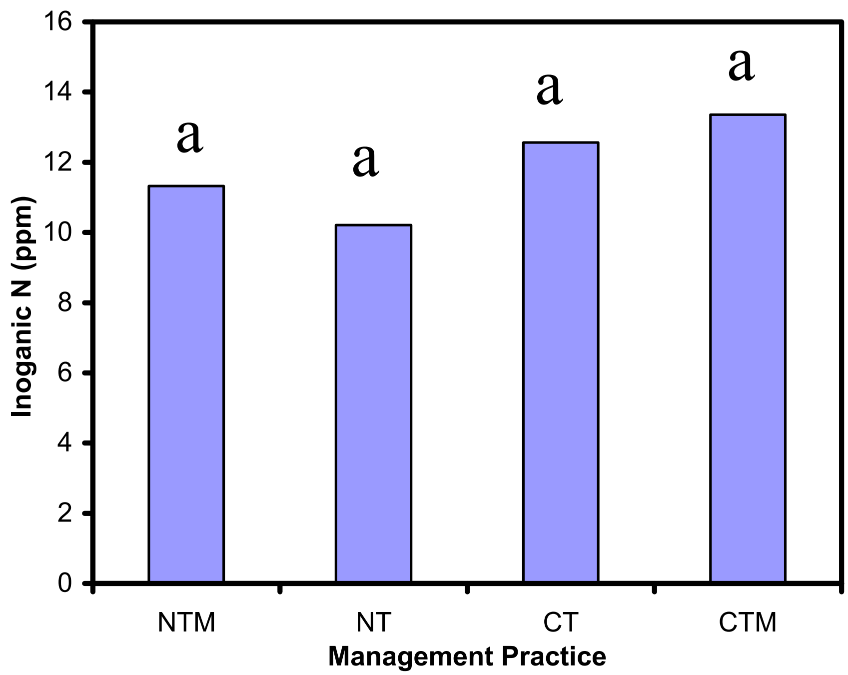

Figure 1. Amount of inorganic N at the initiation of the experiment for the No-tillage with manure (NTM), No-tillage (NT), Conventional Tillage (CT), and Conventional Tillage with manure (CTM) treatments. Values followed by the same letter are not significantly different ($p<0.10$).

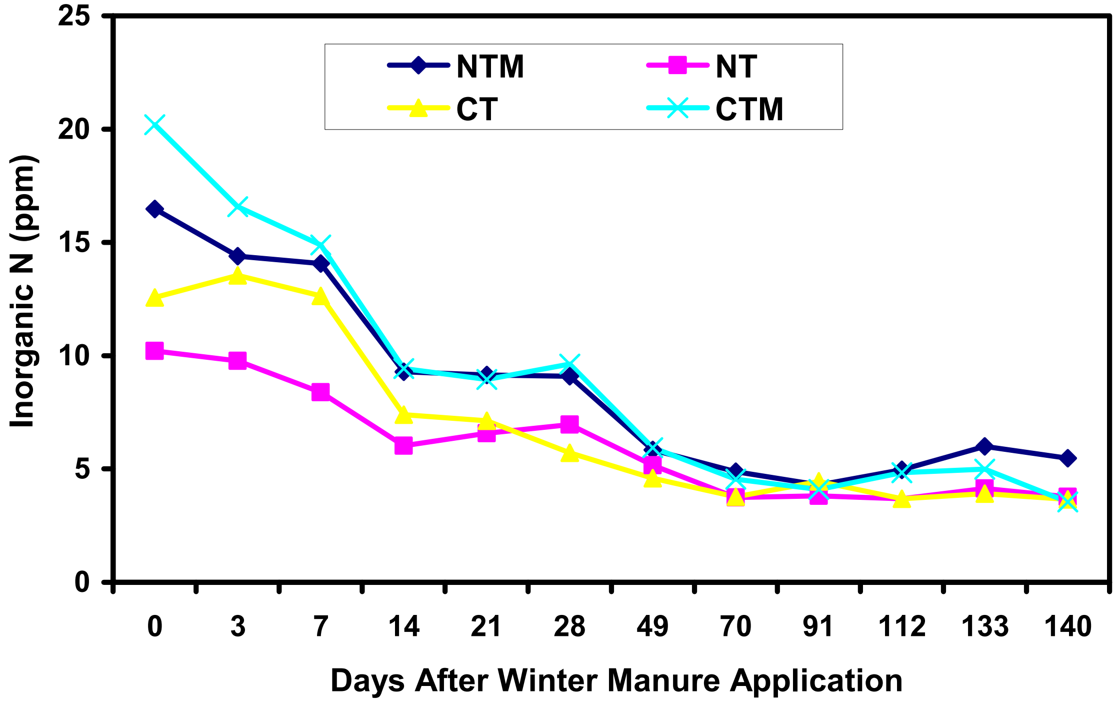

Figure 2. Winter mineralization of N for the No-tillage with manure (NTM), No-tillage (NT), Conventional Tillage (CT), and Conventional Tillage with manure (CTM) treatments.

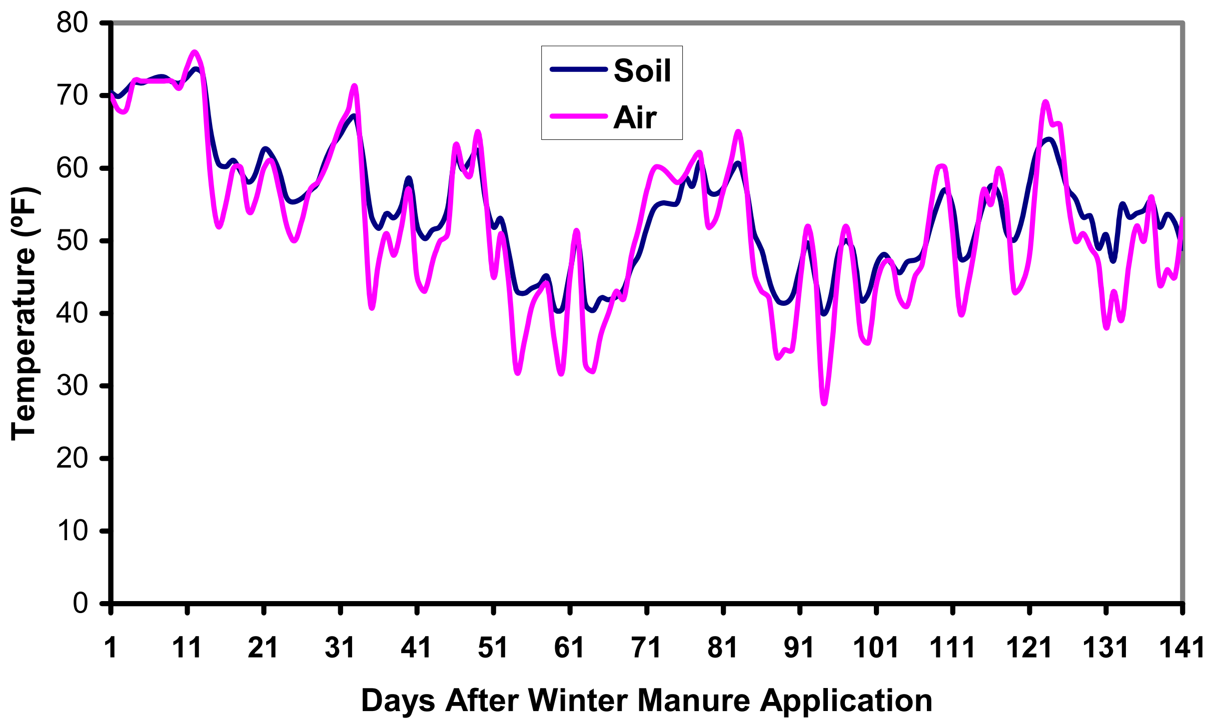

Figure 3. Soil and air temperature of the winter N mineralization study.

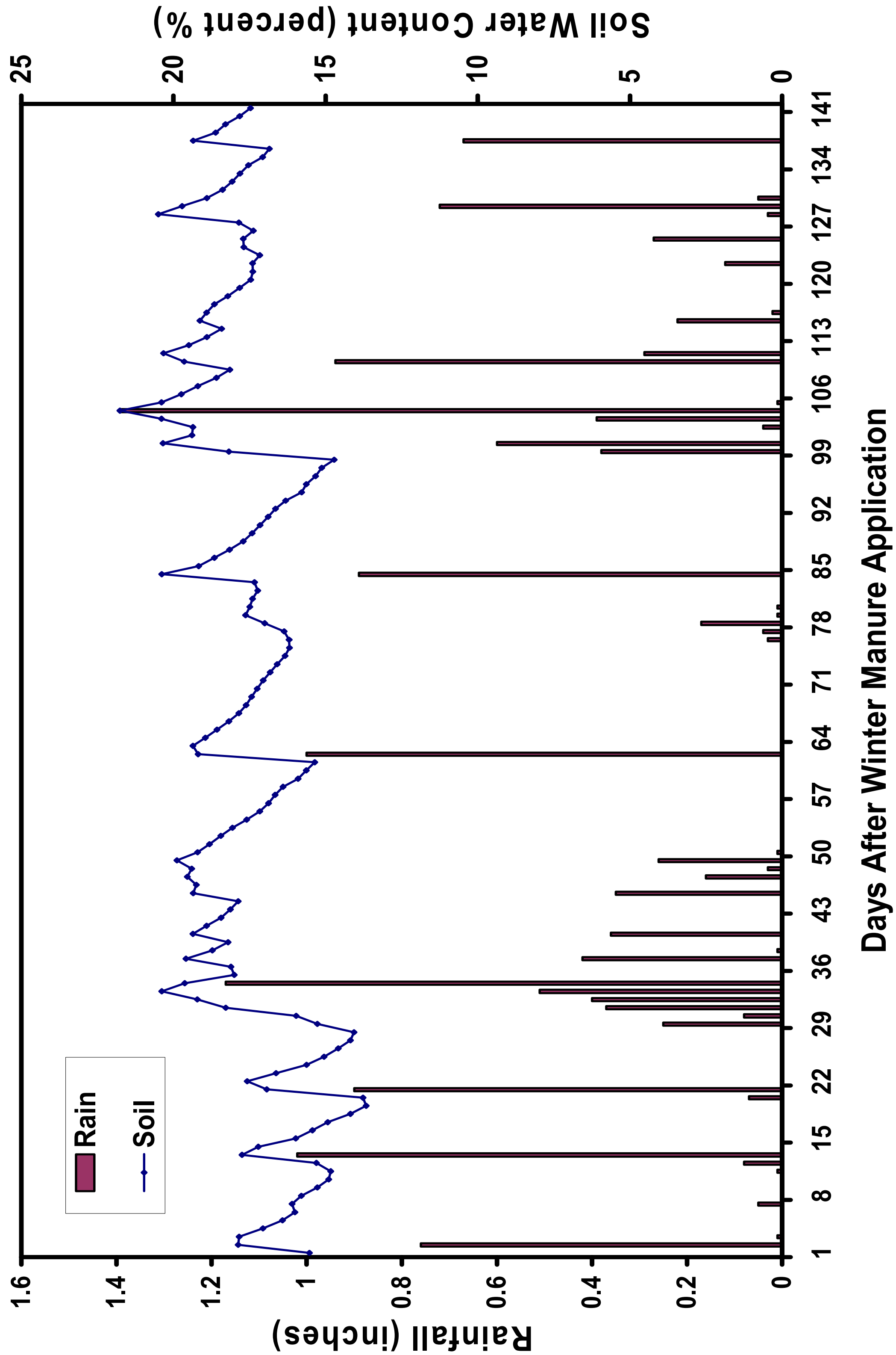

Figure 4. Soil water content and rainfall of the winter N mineralization study.

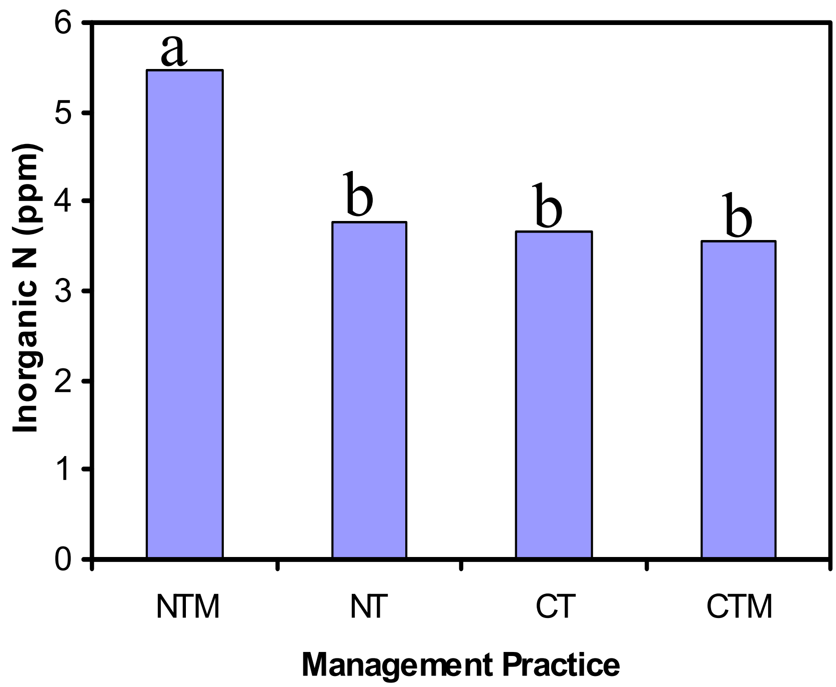

Figure 5. Final inorganic N mineralized for the No-tillage with Manure (NTM), No-tillage (NT), Conventional Tillage (CT), and Conventional Tillage with manure (CTM) treatments. Values followed by the same letter are not significantly different ($p<0.10$).

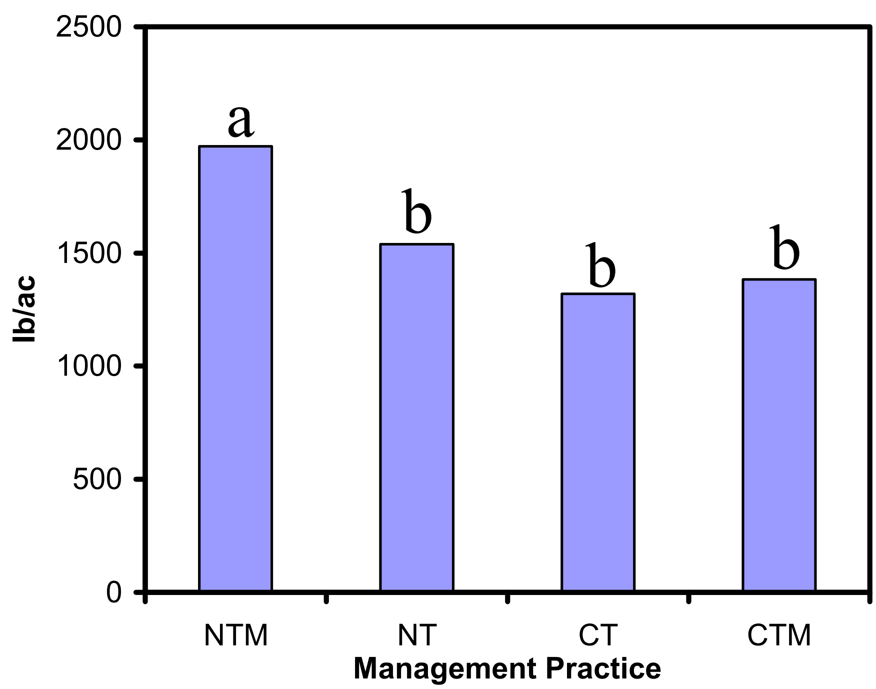

Figure 6. The amount of plant biomass collected for the No-tillage with Manure (NTM), No-tillage (NT), Conventional Tillage (CT), and Conventional Tillage with manure CTM) treatments. Values followed by the same letter are not significantly different ($p<0.10$).

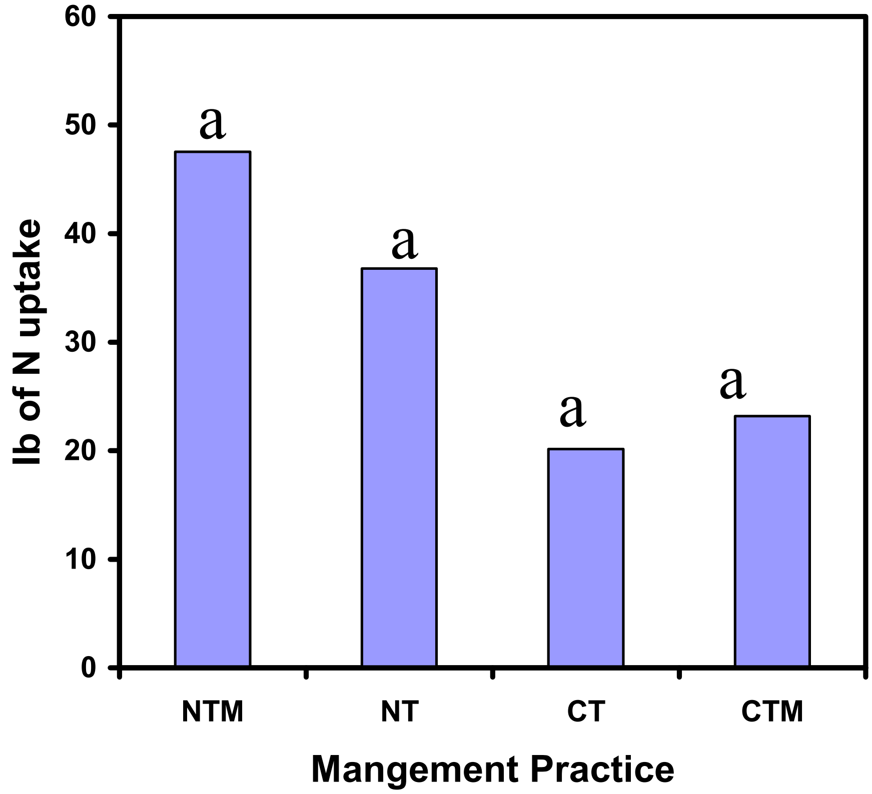

Figure 7. The amount of N taken up in the plant tissue for the No-tillage with Manure (NTM), No-tillage (NT), Conventional Tillage (CT), and Conventional Tillage with manure (CTM) treatments. Values followed by the same letter are not significantly different (p<0.10).