Subsurface band and Surface broadcast Application of Broiler litter: Effect on Soil Nitrogen Spatial Distribution

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ABSTRACT

Nitrogen content of broiler litter is vulnerable to volatilization loss when litter is surface-applied to fields as a fertilizer. Recently, researchers of the USDA-ARS at Auburn, AL have designed a new implement that applies litter in bands under the soil surface. Field research was conducted at the North Farm of the Mississippi Agricultural and Forestry Experiment Station in Starkville, MS to compare the effect of the new subsurface band application and the conventional surface broadcast application of litter on soil nitrogen distribution and concentration. Fertilizer treatments included no fertilizer (control), Broiler litter (BL) surface broadcast before planting at 6720 kg ha^{-1}, and (BL) broiler litter subsurface banded at 20-cm from the center of the cotton row before planting at 6720 kg ha^{-1}. Soil samples were taken at 24 and 73 days after BL application at 0, 10, 20, 30, 40 cm from the cotton row. Soil analysis results showed that application method does have an effect on the available N pool. When the litter was subsurface banded NH_4-N was only elevated 20-cm from the center of the cotton row, where the BL was subsurface banded, 24 days after application. Yet, the average concentration of NH_4-N across all sampled positions at the 0-15 cm depth was 47% greater when PL was subsurface banded than when BL was surface broadcast applied. The subsurface band NO_3-N concentration 24 days after litter application at the 20-cm position was significantly higher than the broadcast and the control and 73 days after litter application at 0-15cm depth, the band NO_3^-N at the same sampling position was 25% higher than the broadcast or the control. These results suggest that applying broiler litter in bands under the surface can have a positive effect on the spatial distribution and concentration of inorganic soil N in close proximity to the root zone of cotton.

INTRODUCTION

The most common method of applying broiler litter to agricultural land is by broadcasting, using a spinning spreader applicator. However, research has shown that surface application of broiler litter results in nutrient losses. The major process of N loss is volatilization of N in the form of the gas NH_3. Sharp et al (2004) evaluated the ammonia volatilization from surface-applied broiler litter under conservation tillage and they found that within 7 to 8 days after applying broiler litter to supply 90 to 140 kg N ha^{-}

[1], the NH_3 flux range from 3.3 to 24% of the total N applied during both the winter and summer.

Cattle and swine slurry are also used as organic fertilizer for row crops. However, when these manures are used, similar to PL surface broadcast application, a percentage of the applied N is lost to volatilization. According to Beauchamp et al. (1982), about 24 to 33% of the ammoniacal N of the liquid cattle slurry is volatilized as NH_3 during a week after application in early May. Safley et al. (1992) reported that using a central pivot to broadcast swine effluent averaged 20% loss of NH_4-N and the traveling gun broadcast system averaged about 26% loss. Due to concerns of N losses through volatilization after surface broadcasting, an alternative application method has been developed, subsurface band application.

The advantages of subsurface banding are (1) fertilizer nutrients are applied in close proximity of plant roots, (2) it allows application after the establishment of canopy in contrast to the broadcast application that is most commonly applied before planting, (3) and it reduces volatilization of N fertilizer. The concept of subsurface banding nutrients has never been applied to broiler litter, so to evaluate the results of a new implementation of subsurface banding PL, the research on subsurface banding or injection of chemical fertilizers and manures is essential. Banding K fertilizers increased corn yields that were under the no-till system in early season drought conditions in Ohio (Yibirin et al., 1993), Iowa (Bordoli and Mallarino, 1998) and Ontario, Canada (Vyn and Janovicek, 2001). Also, Rehm (1995) reported that deep banding K increased K availability and corn yield in ridge-tillage systems. Lehrsch et al. (2000) studied the effect of banding and side dressing N fertilizer on a non-irrigated side of a corn row. They found that compared with broadcast application of fertilizer, the band application maintained grain yield in the first year of the study and increased yield by 11% in the second year. Lamond et al. (1984) reported that knife banding application of urea/ NH_4NO_3 solution (UAN (urea/ammonium nitrate), 280g N kg^{-1} to smooth bromegrass generally resulted in higher yield and protein concentration than broadcast application. Howard and Tyler (1989) evaluated the N efficiency of urea-ammonium nitrate, urea, and urea-urea phosphate when broadcasted, banded, and injected for no-till corn. They reported that yield, leaf N concentration, or N uptake significantly varied among N sources or application methods.

Recent research indicates that broadcasting chemical fertilizer and manures results in substantial N loss through volatilization, but applying fertilizer beneath the soil surface resulted in less N loss with concurrent increased plant yield and nutrient availability. Therefore, the objective of this study is to compare the effect of the new subsurface band application to conventional surface broadcast application of broiler litter on soil N fertility and distribution.

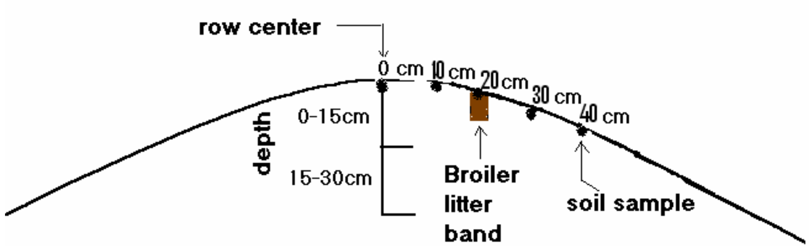
MATERIALS AND METHODS

This research was conducted in 2003 at the North Farm of the Mississippi Agricultural and Forestry Experiment Station in Starkville, MS at the Mississippi State University on a silty clay loam soil. The treatments included a no-fertilizer control, broiler litter (BL) surface broadcast before planting at 6720 kg ha^{-1}, and PL subsurface banded 20-cm from the center of the row before planting at 6720 kg ha^{-1}. A randomized complete block design with 4 replications was used. The plots were 3.9 m x 24.32 m, which included 4 rows with a row spacing of 0.97 m on center. Cotton was grown on conventionally tilled beds.

Broadcast application of broiler litter was accomplished by utilizing a litter spreader that applied litter uniformly across two rows followed by incorporation after several hours using a pre-plant chisel cultivator. The band application was accomplished with a prototype litter spreader (designed and built by scientists from USDA-ARS at Auburn, AL) that creates a 8 x 10 cm trench approximately 20 cm from the center of the cotton row, drops the litter into the trench, and covers it with loose soil within a few seconds. The broiler litter was analyzed for total N using the dry combustion method (Dumas, 1831). Cotton cultivar Delta Pine BR 451 was planted on May 31, 2003 and herbicide mixture of Zorial and Roundup was applied to all plots for weed control.

Systematic soil samples were taken 24 and 73 days after broiler litter application to compare lateral and downward movement of soil N. Systematic soil sampling consisted of taking core samples at later location from the center of the cotton row, 0, 10, 20, 30, 40-cm, at depths of 0-15 and 15-30 cm. This sampling technique is similar to that of Zebarth et al. (1999). The soil samples were analyzed for total N, nitrate-N, and ammonium-N. To determine total N, 0.6g of soil was weighed and analyzed by the dry combustion method mention previously. Ammonium and nitrate concentrations were determined by extracting 2 g of the soil sample with 2 M KCl and analyzing the extract using the Quick Chem Flow injection analyzer 8000 series (Keeney and Nelson, 1982). All analysis was accomplished using ANOVA at 0.05 alpha levels and SAS version 2002.

Fig. 1 Soil sampling model



RESULTS AND DISSCUSSION

Soil total N 30-cm from row center 24 days after litter application was slightly greater when PL was broadcast than when PL was banded (fig. 1). Broadcast total N was significantly higher than the band and control treatments at 15-30cm depth. Total N at the 20-cm position was greater for both the band and broadcast applications than the control. Differences among the three treatments in total N at the other sampling positions and both depths were small. Total N distribution across the sampled positions in the second sampling date was similar to that of the first sampling date.

Ammonium-N concentration at the 20-cm position and 0-15cm depth 24 days after litter application was much greater (17.94 mg/kg) when litter was banded than broadcast (2.34 mg/kg) (Fig. 3). The control had only 1.41 mg/kg ammonium at the same depth. Ammonium concentration at the same position and depth on the second sampling date 73 days after application was also greater when litter was band applied than broadcast applied. At the lower depth 24 days after planting, the band treatment had also gretaer (6.46mg/kg) ammonium concentration than the broadcast or control treatments (1.68 and 1.50 mg/kg, respectively). In addition, at the 40cm position the ammonium concentration of the band treatment (8.72 mg/kg) was also higher than, that of broadcast and the control at 2.54 and 1.86 mg/kg respectively. The ammonium had been depleted at both depths and in both application methods 73 d after application and planting due to plant uptake (Fig. 4). Data from both sampling dates show that band ammonium is greater relative to broadcast at 20 cm from the center of the cotton row where the band is located. At 0, 10, 30, 40-cm positions NH_4-N concentration of the band application was not significantly different from the broadcast application. Zebarth et al., (1982) who investigated the fertilizer banding influence on spatial and temporal distribution of soil inorganic nitrogen in a cornfield found similar results. They reported that when NH_4N0_3 is applied in a fertilizer band the nitrate concentration was elevated at soil sampling positions nearest to the fertilizer band at both depth 0-15 and 15-30cm.

Broadcasting litter resulted in a significantly higher concentration of NO_3-N at 0-cm from the cotton row and 0-15cm depth than the band and control treatments 24 days after litter application (fig. 5). But, at the lower depth and 0-cm position sampled, the broadcast treatment NO_3-N concentration was only 5% higher than band and 11% higher than the control. At 10-cm from the center of the cotton row, when litter is banded relative to broadcast, there was a 15% increase in the concentration of NO_3-N and a 28% increase when compared to the control 24 days after litter application at the 0-15cm depth. The increase in soil nitrate 10-cm from the row could be due the movement of NO_3-N from where the PL band was applied at 20-cm form the row. This indicates that plant roots are most likely to encounter a larger soil NO_3-N pool when PL is band compared to broadcast applied.

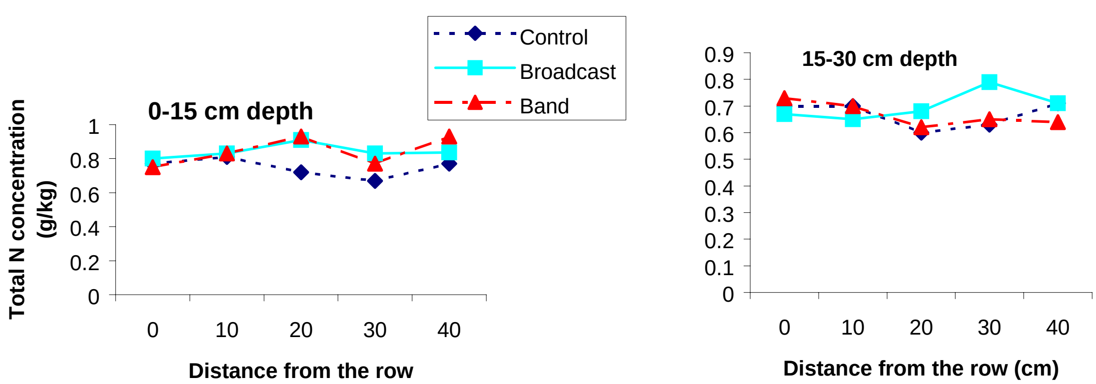


Fig. 2. Soil total N concentrations 24 days after application at the 0-15 and 15-30 cm depths at different distances from the center of the row on June 23, 2003.

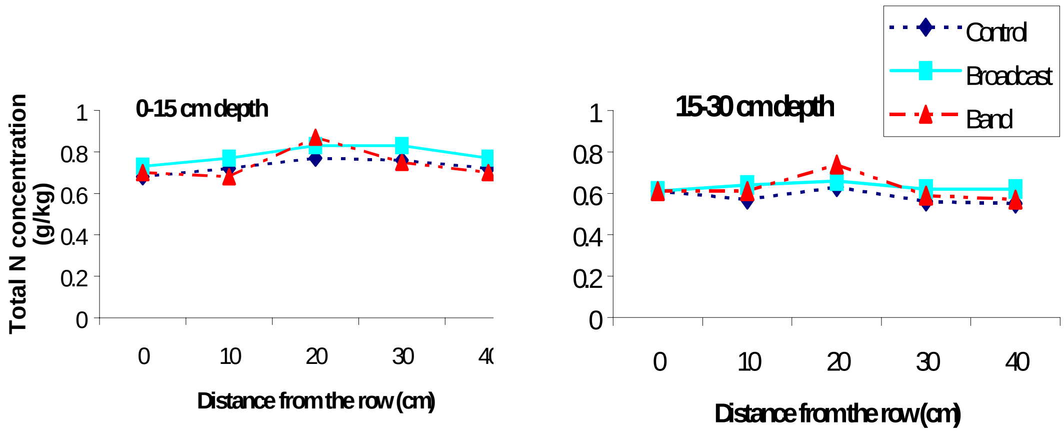


Fig. 3. Soil total N concentrations 73 after application at the 0-15 and 15-30 cm depths on Aug. 11, 2003.

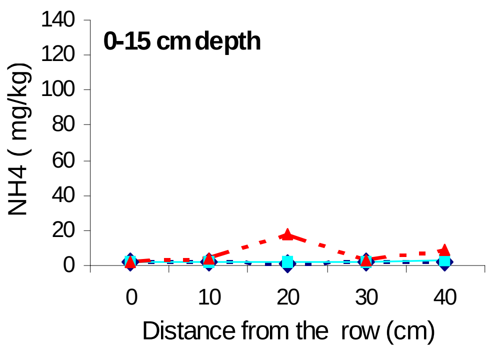


Fig. 4. Soil NH_4-N concentrations 24 days after application at the 0-15 and 15-30 cm depths at different distances from the center of the row in June 23, 2003

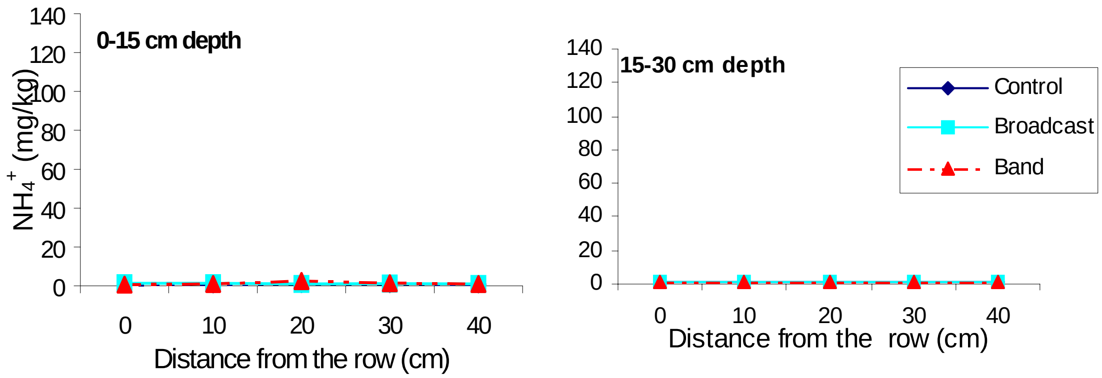


Fig. 5. Soil NH_4-N concentrations 73 days after application at the 0-15 and 15-30 cm depths at different distances from the center of the row in Aug. 11, 2003

At the lower depth and 10-cm position, the broadcast NO3- was slightly higher than the band and control NO_3-N 24 days after litter application. Finally, at the 40cm position the band NO_3-N concentration was 7% higher than broadcast at 24 days after litter application at the 0-15cm depth and at the 15-30 cm depth the broadcast NO_3-N was 6% higher than band and 10% higher than the control.

The band NO_3-N concentration 24 days after litter application at the 20-cm position was significantly higher than the broadcast and the control. At the lower depth the broadcast application was greater than band and the control. On the second sampling data 73 days after litter application and at 0-15cm depth, the band NO_3-N at the same sampling position was 25% higher than the broadcast or the control treatments. At the deeper depth and the 20-cm sampling position, the band NO_3-N concentration (7.9 mg/kg) was higher than the broadcast (2.69mg/kg) and the control (1.90 mg/kg) treatments. These results are also similar to the results of Zebarth et al. (1982) with applied inorganic N.

At the 0-15 cm depth and 30-cm from the center of the cotton row, when litter is banded there is 20% increase in the NO_3-N concentration compared to when litter is broadcasted at the same rate (Fig. 5). In addition, at the 15-30 cm depth the band NO_3-N was 26% higher than broadcast NO_3-N concentration. So, movement of NO_3-N 10cm on either side of the PL band resulted in an increase in band soil NO_3-N compared to broadcast. However, data from the second soil sampling show that there was a decrease in the concentration of NO_3-N that could be due to plant uptake and leaching.

Fig. 6. Soil NO_3-N concentration 24 days after application at 0-15 and 15-30 cm depths at different distances from the center of the row on June 23, 2003.

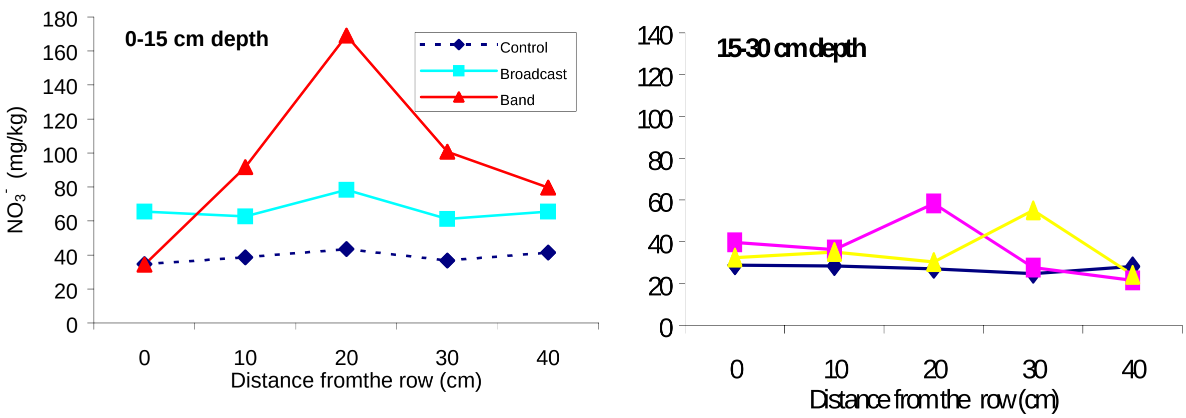
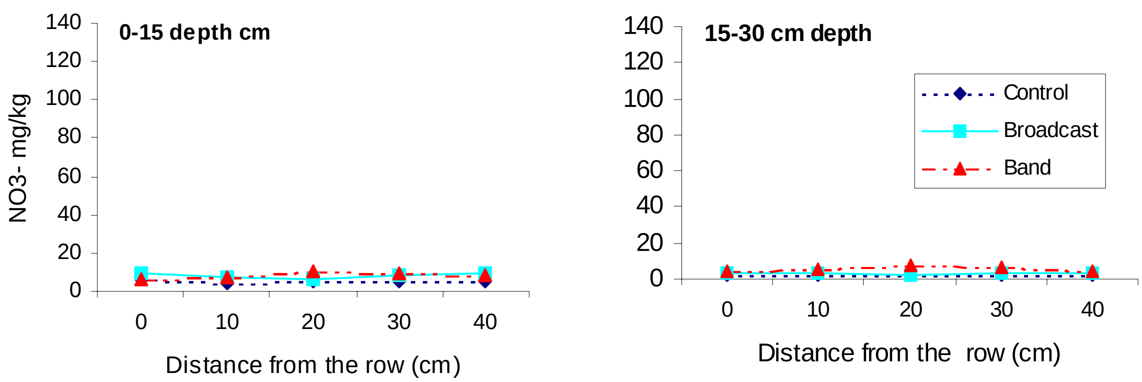


Fig. 7. Soil NO_3-N concentration 73 days after concentration at 0-15 and 15-30 cm depths at different distances from the center of the row in Aug. 11, 2003.



SUMMARY

Spatial data, at five positions from the center of the row, has indicated that nitrate is mobile when BL is band applied. Also the data show that the nature of the application method does have an effect on the available N nutrient pool. When the broiler litter was banded, ammonium 24 days after application was only elevated at 20-cm, where the band was located. However, the average concentration of NH_4-N across all sampled positions at 0-15 depth was 47% higher when PL was banded relative to broadcast applied. Band NO_3-N concentration was significantly greater 24 days after application at 20 cm from the center of the cotton row and 0-15 cm depth, compared to when litter is broadcast applied. Broiler litterbanded in close proximity to the root zone resulted in a higher concentrations of soil inorganic N.

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