Long term Application of Poultry Broiler Litter to Cotton and Corn

C. C. Mitchell[1] and W. C. Birdsong[2]

[1]Agronomy & Soils Dept., Auburn University, AL 36849 USA

[2]Wiregrass Research & Extension Center, P.O. Box 217, Hwy 134E Headland, AL 36345 USA

Corresponding author's e-mail: cmitchel@acesag.auburn.edu

ABSTRACT

Poultry broiler litter has been applied to crops on a Coastal Plain soil (fine-loamy, siliceous, thermic Typic Kandiudults) since 1991 in Alabama. Variable N rates from 0 to 240 lbs acre-1 were applied based upon the total N content of poultry broiler litter and compared to fertilizer N rates as ammonium nitrate. Conventionally tilled cotton was produced 1991-1994; conservation tilled corn was planted 1995-1997; and conservation tilled cotton has been planted since 1998 to evaluate surface applications and residual effects of broiler litter on cotton. The relationship between the N rates (N) and relative N availability (y) based on the crop yield can be described by linear equation: y=71.58+0.15N (r=0.66*, n=22). Residual effect of broiler litter the year following application produced 30 to 50% cotton lint yield and 25 to 65% corn grain yield relative to the current season's application. General observations suggest that N availability from broiler litter is similar whether surface applied as in conservation tillage systems or incorporated as in conventionally tilled systems.

KEYWORDS

Manure, broiler litter, poultry litter, cotton, corn, nitrogen availability, nitrogen fertilization

INTRODUCTION

Alabama produces almost 3 times more poultry broiler litter (by weight) as commercial fertilizers used. In regions of intensive poultry production, most broiler litter is over applied to pastures and hayfields creating potential nutrient enrichment of surface and ground waters. Row crop farmers have been reluctant to use broiler litter on their crops, especially cotton. Reasons may include:

- Perception among cotton producers that manure-N sources would produce excessive vegetative growth and late maturity of cotton.
- Suspicion that animal manures may introduce weed seed into prime cotton land.
- Lack of extensive published, applied research with manures on cotton.
- Most cotton land is often remote from the smaller farms where poultry is produced
- Availability of broiler litter may not coincide with optimum time of fertilizing cotton at planting in the spring.
- Reluctance of cotton producers to change successful production practices.

In 1990, an experiment began at the Tennessee Valley Research and Education Center in North Alabama to address concerns about the use of broiler litter on cotton. This experiment was discontinued after the 1993 growing season (Mitchell *et al*., 1995. Broiler litter on cotton. 1995 Proc. Beltwide Cotton Conf. p. 1338-1339. Nat. Cotton Council. Memphis, TN.). An identical experiment was started at E.V. Smith Research Center in Central Alabama in 1991 and has continued with modifications for over 10 years. Today, it is one of the longest running, continuous experiments in the U.S. with poultry manure on crops.

The objectives of the experiment over the years have been to:

1) evaluate broiler litter as a source of N for cotton and corn;
2) determine the availability of N in broiler litter compared to ammonium nitrate fertilizer;
3) determine if plant growth regulators would be needed to control excessive vegetative growth of cotton fertilized with broiler litter;
4) determine the residual effects of broiler litter on cotton and corn production and soil properties; and
5) demonstrate to area producers the practicality of using broiler litter as an alternative fertilizer for cotton.

IN E. van Santen (ed.) 2002. Making Conservation Tillage Conventional: Building a Future on 25 Years of Research. Proc. of 25th Annual Southern Conservation Tillage Conference for Sustainable Agriculture. Auburn, AL 24-26 June 2002. Special Report no. 1. Alabama Agric. Expt. Stn. and Auburn University, AL 36849. USA.

Table 1. Mean values of broiler litter on an as-sampled basis (n = 11) that was used in test from 1991 through 2001.

Analysis	Mean	SE	Min.	Max.
Moisture, %	24.4	9.20	14.4	38.5
Ash, %	27.3	6.70	20.5	37.4
Total N, %	2.98	0.63	2.04	4.14
NH_4-N, %				
P_sO_5, %	3.92	0.40	3.37	4.75
K_2O, %	2.80	0.53	1.80	3.56
Ca, %	2.43	0.24	2.01	2.89
Mg, %	0.54	0.05	0.47	0.60
Cu, mg kg^{-1}	508	154	300	751
Zn, mg kg^{-1}	401	86	250	562
Mn, mg kg^{-1}	439	138	310	669
Pb, mg kg^{-1}	14	6.00	9	21
B, mg kg^{-1}	51	10	39	71

METHODS

The site of the experiment is on the Field Crops Unit of E.V. Smith Research Center in Central Alabama. The site is in the Upper Coastal Plain soil physiographic region and the soil is mapped as a Norfolk fine sandy loam (fine-loamy, siliceous, thermic Typic Kandiudults).

Conventionally tilled cotton was grown from 1991-1994, corn from 1995-1997, and conservation tilled cotton since 1998. The experiment contains 11 treatments replicated 4 times. Treatments are different rates of broiler litter or ammonium nitrate based solely upon the TOTAL N in the material.

All broiler litter is broadcast just prior to planting at a rate based upon the TOTAL N concentration in the litter (Table 1); ammonium nitrate rate is split with 1/2 applied at planting and 1/2 applied as a sidedress. All treatments except broiler litter treatments receive 60 pounds P_2O_5 and 60 pounds K_2O per acre as concentrated superphosphate and muriate of potash, respectively, just prior to planting.

When conventionally tilled cotton was planted (1991-1993), Pix® (mepiquot chloride) was used on half of the broiler litter treatments to determine if a plant growth regulator was needed. Approximately 8 total ounces per acre were applied in multiple applications. This treatment was dropped when conservation tilled corn was planted in 1995 and conservation tilled cotton in 1998. Residual broiler litter treatments in 1995-2001 received no additional fertilization the year after application. Since 1995, the broiler litter treated plots and residual broiler litter plots have rotated.

Conventional tillage included using a moldboard plow, disk, field cultivator, and cultivator to control weeds. Plots were winter fallowed, and all nutrients were incorporated just prior to planting under conventional tillage. Conservation tillage followed winter rye planted as a cover crop; all nutrients were surface applied just prior to planting into rye residue after spraying with glyphosate. All rows were in-row subsoiled to 35 cm every spring just prior to planting. There was no mechanical cultivation. Yields were estimated by harvesting the two center rows in each 8-row plot.

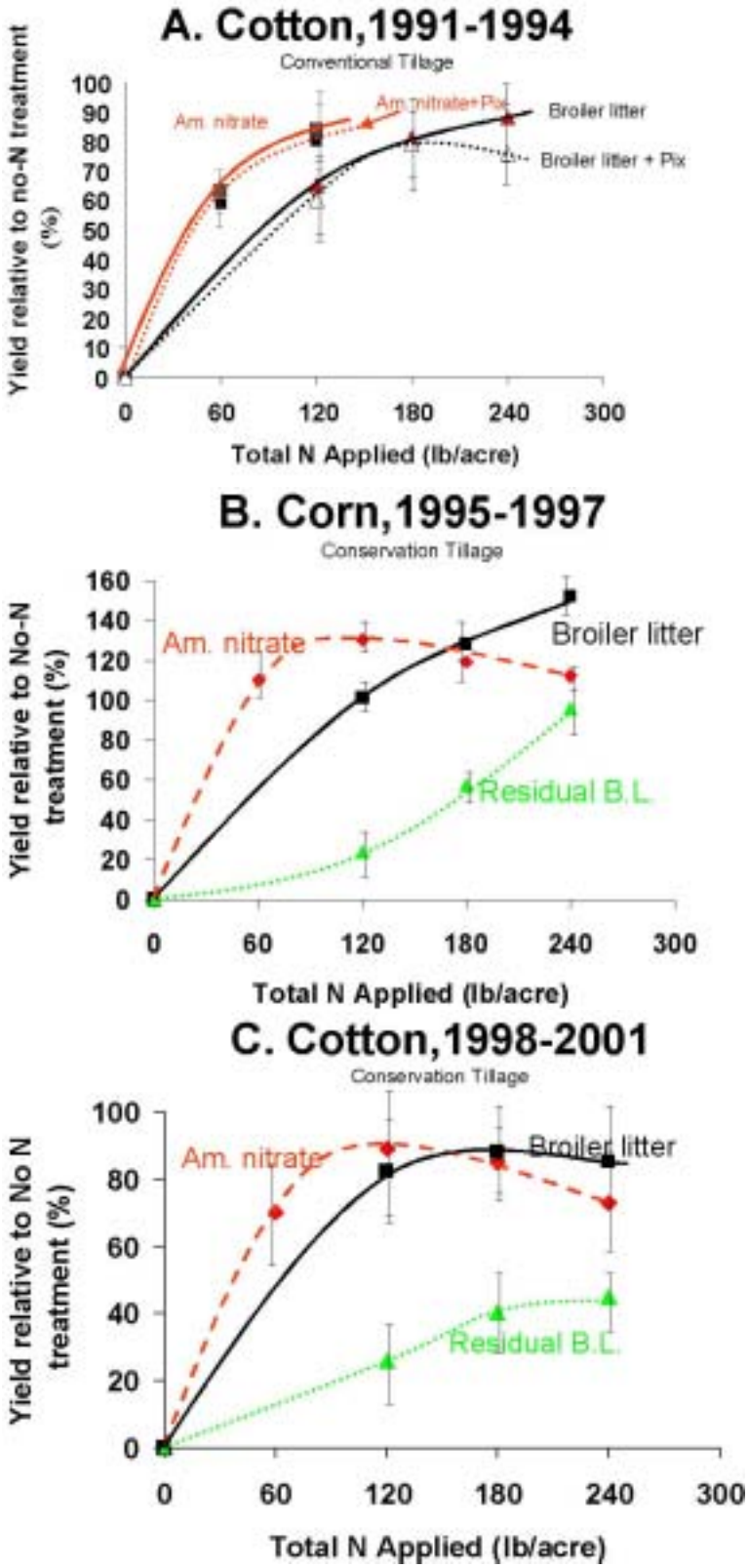
RESULTS

Because this is a non-irrigated study, yields varied considerably from year to year depending upon rainfall (Table 2). However, high cotton lints yields are near 2 bales per acre

Table 2. Highest average cotton and corn yields produced on this study by year, 1991-2001.

Year	Highest yield	Treatment
Cotton, conventional tilled (lbs lint $acre^{-1}$)		
1991	1200	Broiler litter @ 180 lbs N $acre^{-1}$
1992	990	Broiler litter @ 240 lbs N $acre^{-1}$
1993	911	Broiler litter @ 180 lbs N $acre^{-1}$
1994	990	Am. nitrate @ 120 lbs N $acre^{-1}$
Corn grain, conservation tilled (bu $acre^{-1}$)		
1995	70	Broiler litter @ 240 lbs N $acre^{-1}$
1996	133	Am. nitrate @ 120 lbs N $acre^{-1}$
1997	153	Broiler litter @ 240 lbs N $acre^{-1}$
Cotton, conservation tilled (lbs lint $acre^{-1}$)		
1998	855	Am. nitrate @ 120 lbs N $acre^{-1}$
1999	1020	Broiler litter @ 120 lbs N $acre^{-1}$
2000	812	Broiler litter @ 240 lbs N $acre^{-1}$
2001	1520	Broiler litter @ 240 lbs N $acre^{-1}$

Fig. 1. Average cotton lint and corn grain yields relative to the no-N check as affected by total N rate applied as ammonium nitrate and poultry broiler litter. Residual B.L. is the relative yield the year following broiler litter application where no additional fertilizer was applied.



with the exception of 1998 and 2000. Over 3 bales per acre were produced in 2001 using the highest rate of broiler litter. Corn grain yields were very good for Central Alabama in two of the three years. Mean yields are presented in Tables 3 and 4.

In general, the total N in broiler litter is only slightly less available to crops compared to nitrogen from ammonium nitrate fertilizer. Under conventionally tilled cotton from 1991-1994 (Figure 1a.), we needed between 180 and 240 pounds total N as broiler litter to produce the same cotton lint yield as 120 pounds N per acre as ammonium nitrate. These first years of the study seemed to support Alabama Cooperative Extension recommendations that about 2/3 of the total N in broiler litter would be available to the crop the year it was applied. The plant growth regulator, Pix®, had no significant affect on cotton yield.

In 1995 when conservation tilled corn was planted, we began rotating the treatments receiving broiler litter so we had 1-yr residual broiler litter treatments. Ammonium nitrate treatments were increased to match the total N applied in broiler litter. The average over three years of corn indicated that about 160 pounds total N in broiler litter (surface applied at planting) was needed to produce the same corn yield as 120 pounds N as ammonium nitrate in split applications (Figure 1b.) There is significant carryover of N from broiler litter treatments into the second year. Although the presidedress soil nitrate test failed to detect any residual nitrate-N to a depth of 2 feet (data not shown) the crop was certainly able to respond to residual N. However, residual N from the highest broiler litter application rate the previous year failed to produce yields equivalent to 60 pounds N per acre as ammonium nitrate.

Surprisingly, nitrogen availability is about the same whether it is surface applied as in conservation tillage or incorporated as in conventional tillage. In fact, from 1998-2001 we needed about 140 pounds N as broiler litter surface applied to produce the same cotton yield as 120 pounds N as ammonium nitrate. We see a similar pattern

Table 3. Mean cotton lint yields for conventionally -tilled cotton, 1991-1994.

N source	Total N	Cotton yield†	
	-- lbs acre^{-1}--	-----lbs lint acre^{-1}---	
No N	0	550	d
Am. nitrate	60	840	bc
Am. nitrate	60 + Pix	840	bc
Am. nitrate	120	940	abc
Am. nitrate	120 + Pix	940	abc
Broiler litter	120	880	abc
Broiler litter	120 + Pix	850	bc
Broiler litter	180	960	a
Broiler litter	180 + Pix	950	ab
Broiler litter	240	970	a
Broiler litter	240 + Pix	940	abc

†Means followed by the same letter are not significantly different at $P = 0.05$.

of residual N from broiler litter on cotton yield, although cotton is not as responsive to N as corn.

When all data for the 11-yr experiment are combined in an attempt to estimate an availability factor for broiler litter for cotton and corn, we found that at about 186 pounds total N, the availability of N from broiler litter is the same as that from ammonium nitrate (Fig. 2). High rates of broiler litter seem to enhance crop growth above and beyond what can be explained by nitrogen fertility alone. This has been documented before and may be attributed to increased soil organic matter, improved soil physical condition, enhanced growth of beneficial soil microorganisms, control of certain soil borne pathogens e.g. nematodes, plant growth regulators produced by decomposing broiler litter, *et cetera*. At a N rate of 120 pounds N per acre, which is the recommended N rate for non-irrigated corn in Alabama and is the optimum N rate as ammonium nitrate for cotton on this site (Fig. 1), the N availability factor for broiler litter is 90%.

Fig. 2. Nitrogen availability from poultry broiler litter compared to ammonium nitrate for cotton and corn, 1991-2001.

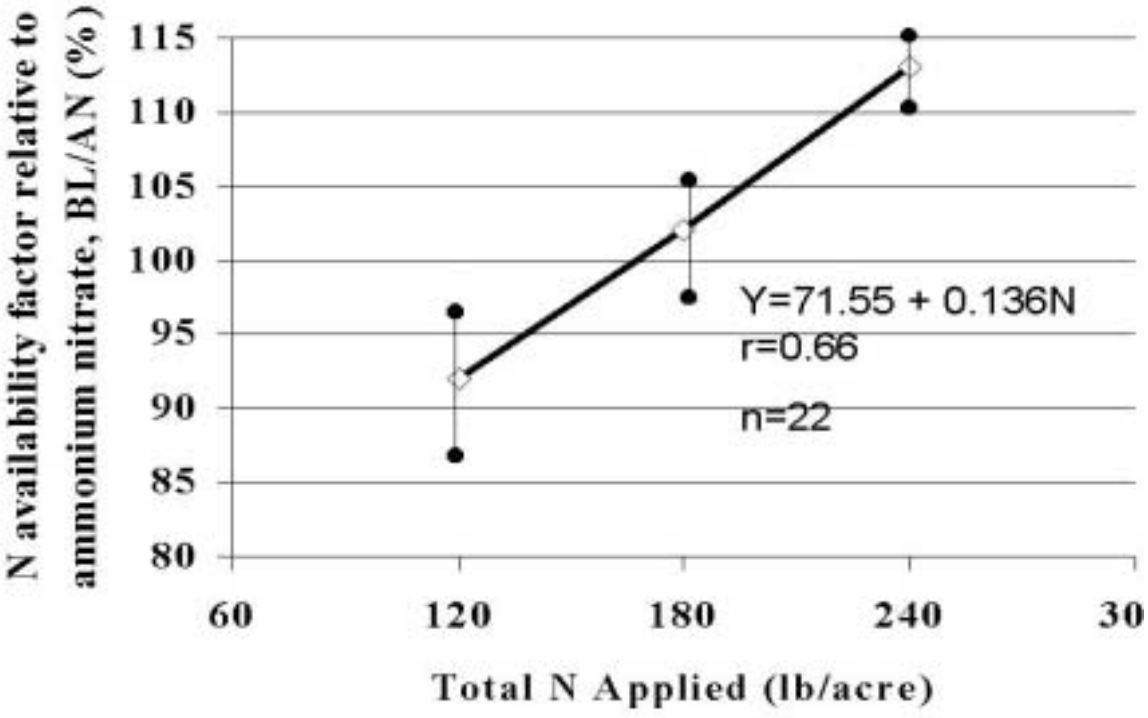


Table 4. Mean yields for conservation-tilled corn (1995 - 1997) and cotton (1998- 2000)

N source	Total N rate	Corn, 1995-1997*		Cotton, 1998-2001†	
	--- lbs acre^{-1} --	----- bu acre^{-1} -----		---- lbs lint acre^{-1} --	
No N	0	46	e	540	c
Am. nitrate	60	99	bc	940	a
Am. nitrate	120	107	ab	1030	a
Am. nitrate	180	103	abc	990	a
Am. nitrate	240	98	bc	940	a
Broiler litter	120	107	ab	990	a
Broiler litter	180	103	abc	1020	a
Broiler litter	240	117	a	1040	a
Broiler litter	120 Residual	58	e	680	b
Broiler litter	180 Residual	73	d	760	b
Broiler litter	240 Residual	89	c	780	b

† Means followed by the same letter are not significantly different at $P = 0.05$.

CONCLUSIONS AND RECOMMENDATIONS

Over ten years of research with broiler litter on cotton and corn on a Central Alabama Coastal Plain soils have demonstrated that broiler litter can be used as the sole N source for cotton. Broiler litter may all be applied at planting and rates can be based upon the total N in broiler litter. Rates do not need adjusting when surface applied and not incorporated as in conservation tillage systems. Residual N from broiler litter on cotton is small but significant. On fields that have not received previous applications of broiler litter, assume a N availability factor of 2/3. However, because of the residual effect of N two years after application, long-term availability factors will be around 90% at recommended N rates.