COTTON YIELD RESPONSE TO THE APPLICATION OF ORGANIC AND INORGANIC NITROGEN

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Abstract

The increased concentration of poultry industries in certain parts of the Southeastern United States is leading to serious poultry waste disposal problems. As part of on-going safe litter disposal studies, fresh and composted poultry litter with and without a nitrification inhibitor, carboxymethyl pyrazole (CMP), were applied to cotton (*Gossypium hirsutum cv* DPL-51) to provide 45N, 90N, or 135N kgha^{-1}. The study was conducted in 1994 at the Tennessee Valley Sub-station, Belle Mina, Alabama. All sources of nitrogen increased cotton lint yields significantly from 1280 kgha^{-1} in the control plot. CMP had no effect on cotton yield. Fresh poultry litter (1650 kgha^{-1}) improved cotton yields significantly more than urea (1520 kgha^{-1}) or composted poultry litter (1520 kgha $^{-1}$). These results indicate that fresh poultry litter can be substituted for inorganic N sources in cotton production in the Tennessee Valley Region.

Introduction

Poultry production is growing rapidly in the Southeastern Region of the United States; production since 1986 has increased 48% in Alabama alone (Molnar and Wu, 1989). Alabama produces approximately 847 million broiler chickens annually, and production is expected to double by the end of the century. This industry produces 1.7 million tons or more of poultry litter annually as a by-product in Alabama (Link and Thomas, 1981).

There is a growing concern that the indiscriminate disposal of poultry litter could cause groundwater contamination with nitrates and eutrophication of lakes and water sources due to surface run-off phosphorus (Sallade and Sims, 1992). Nitrate leaching and soil overloading of P from repeated poultry litter applications have already occurred on much of this land or will occur soon (Wood, 1992). This study was initiated to explore poultry litter's potential use as an alternative nitrogen source for cotton, and to evaluate the effect of an experimental nitrification inhibitor, *carboxymethyl pyrazole* (CMP), on enhanced ammonium nutrition and consequent nitrate leaching.

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Materials and Methods

This research was conducted at the Tennessee Valley Substation of Auburn University, Belle Mina, about 20 miles west of Huntsville, AL. It is a concentrated cotton growing area adjacent to concentrated broiler production in north Alabama. The experimental site is a Decatur silt loam. The experimental design was a randomized complete block design with three fertilizer types (urea, fresh poultry litter, and composted poultry litter), two nitrification inhibitors levels (with and without), and four nitrogen levels (0, 45N, 90N, and 135N kgha^{-1}). The treatments were replicated four times. The chemical analyses of soils sampled prior to application of treatments are given in Table 1. A blanket application of 336 kgha^{-1} of 0-20-20 fertilizer was applied as a basal dose to all plots resulting in 67.2 kgha^{-1} of P_2O_5 and K_2O to nullify the effects of P and K additions through poultry litter applications. The fresh poultry litter and composted poultry litter were prepared at the Environmental Research Center (ERC) of the Tennessee Valley Authority (TVA). The fresh poultry litter was received from poultry farms and kept at TVA for three weeks prior to application. The fresh poultry litter had 2.8%N, 1.28%P, 2.1%K and C:N ratio of 9.1:1.

The composted poultry litter that was received from the poultry house was mixed with sawdust to reduce the C:N ratio. Two piles, approximately 10 feet in diameter and 5 feet high each, were constructed using 6410 pounds of fresh litter and 3590 pounds of water per pile. A front end loader was used to construct the piles. An overhead crane with a clam shell bucket was used to aerate the piles. The piles were aerated every day for the first 35 days, then twice a week for the next eight weeks. For the next six months, when the oxygen level dropped below 5%, the piles were aerated. The compost reached a maximum temperature of 150°F and maintained that temperature for 30 days. After the thirty days, the broiler litter contin-ued to compost, maintaining a temperature of over 100°F for six months. The litter was composted for nine months. The final analysis of the finished compost was 1.88%N, 1.7%P, 2.7%K and C:N ratio of 8.8 to 1.

The nitrification inhibitor CMP (*Carboxymethyl pyrazole*) was obtained from the Department of Botany and Plant Pathology, Purdue University. It is an experimental nitrification inhibitor, 2 to 4 times more effective and much less volatile than nitrapyrin. It was applied at the rate of 0.56 kgha^{-1} active ingredient per acre. The inhibitor was diluted in a 50:50 solution of ETOH and acetone. The inhibitor was sprayed directly on the urea and poultry litter prior to field application, and it was also sprayed directly on the soil in the control plot. The treatments were applied by hand directly to the plots and immediately incorporated with disk harrow and two days later the cotton seeds were planted. The total rainfall during the year was 156.85 cm (Table 2). Since there was adequate rain for cotton production during the year, only 1.27 cm irrigation water was applied.

As the initial statistical analysis did not indicate any difference in cotton yield due to the nitrification inhibitor. Treatments with CMP inhibitor (10 treatments and 40 plots) were grouped together and compared to treatments without CMP (10 treatments and 40 plots) using the contrast procedure of the Statistical Analysis System (SAS).

Similar contrast procedures were used to compare the effects of sources of nitrogen (Tables 3 and 4). In these analyses, three levels of N and two levels of CMP were combined. Similarly, the sources of N and CMP levels were combined to understand the effects of rate of N on cotton production (Tables 5, 6, and 7).

Results and Discussion

The treatments with and without the nitrification inhibitor CMP produced the same amount of cotton yield, 1530 kgha^{-1}. The fresh poultry litter produced significantly higher (1650 kgha^{-1}) cotton yield compared to urea (1520 kgha^{-1}) and composted poultry litter (1520 kgha^{-1}) (Tables 3 & 4). The composted poultry litter did not perform like fresh poultry litter; this might be due to tying up of nitrogen by microbial populations in the composting process.

Higher N levels, 90N and 135N kgha^{-1}, produced 110 and 190 kgha^{-1} more cotton yield than 45N kgha^{-1} (Tables 5 and 6); the 135N kgha^{-1} produced 80 kgha^{-1} more cotton yield than 90N kgha $^{-1}$ (Table 7). The cotton production trends of the nitrogen sources are shown in Figure 1. The composted poultry litter produced higher cotton yield than urea at 45N kgha^{-1} but lower at 90N and 135N kgha $^{-1}$. This cannot be explained. The fresh poultry litter and urea treatments increased cotton yield as the rate of nitrogen increased. The fresh poultry litter improved cotton yield better than urea and composted poultry litter in all the three nitrogen rates under investigation (Figure 1). The intercept (1328 kgha^{-1} of lint) of the regression program indicates that 1994 was a good season for cotton production in the region. Overall, an additional 1.8 kg of cotton was produced for every kg of N applied.

Conclusion

The organic source of nitrogen, fresh poultry litter, produced cotton yield significantly (P>0.05) higher than did the inorganic source of nitrogen, urea. Fresh poultry litter has good potential to be used as an alternative nitrogen source for cotton production in the Tennessee Valley.

References

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TABLE 1. Chemical analysis of experimental field prior to treatment application, 1994

SOIL depth	Total N	P	K	Ca	Mg	Cd
(cm)	(%)	- - - - - - -Extractable (PPM)- - - - - - -				
0-15	0.070	10.63	83.48	1368.8	53.75	1.75
15-30	0.056	6.93	69.08	1229.73	53.35	1.50
30-45	0.056	1.90	24.65	1248.05	51.35	1.75
45-75	0.059	2.78	21.40	1156.88	72.00	1.50
75-105	0.500	4.48	21.98	851.25	83.90	1.25
105-135	0.490	5.08	26.18	672.93	82.70	1.75

TABLE 2. Rainfall at the Tennessee Valley sub-station, Auburn University, Belle Mina, AL, (month/cm) 1994

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec
15.54	23.11	21.84	6.30	14.58	18.85	10.08	4.04	10.26	14.12	11.48	6.59

TABLE 3. Effect of source of nitrogen (mean of 45N, 90N, and 135N kgha^{-1}) levels on cotton yield, 1994, Belle Mina

TREATMENT	COTTON YIELD
	(kgha^{-1})
Urea	1520b
Fresh Poultry Litter	1650a

Treatment means are significantly different at the 0.0045 probability level.

TABLE 4. Effect of source of nitrogen (mean of 45N, 90N, and 135N kgha^{-1}) levels on cotton yield, 1994, Belle Mina

TREATMENT	COTTON YIELD
	(kgha^{-1})
Fresh Poultry Litter	1650a
Composted Poultry Litter	1520b

Treatment means are significantly different at the 0.0016 probability level.

TABLE 5. Effect of 45N vs 90N kgha^{-1} (mean of urea, fresh and composted poultry litter sources) on cotton yield, 1994, Belle Mina

TREATMENT	COTTON YIELD
	(kgha^{-1})
45N kgha^{-1}	1460b
90N kgha^{-1}	1570a

Treatment means are significantly different at the 0.0115 probability level.

TABLE 6. The Effect of 45N vs 135N kgha^{-1} (mean of urea, fresh and composted poultry litter sources) on cotton yield, 1994, Belle Mina

TREATMENT	COTTON YIELD
	(kgha^{-1})
45N kgha^{-1}	1460b
135N kgha^{-1}	1650a

Treatment means are significant different at the 0.0001 probability level.

TABLE 7. The Effect of 90N vs 135N kgha^{-1} (mean of urea, fresh and composted poultry litter sources) on cotton yield, 1994, Belle Mina

TREATMENT	COTTON YIELD (kgha^{-1})
90N kgha^{-1}	1570b
135N kgha^{-1}	1650a

Treatment means are significantly different at the 0.0682 probability level.

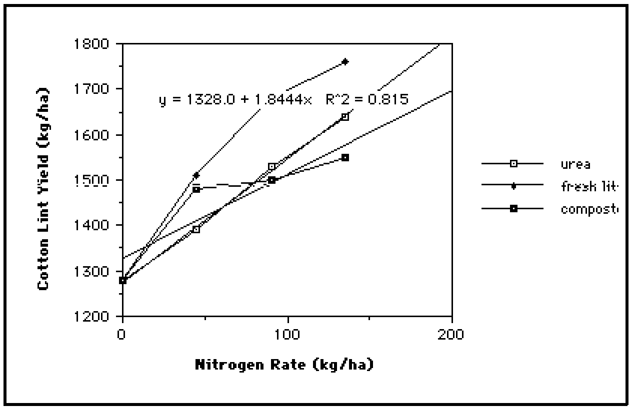

FIGURE 1. Cotton lint yield response to 45N, 90N, and 135N kgha^{-1} applied through different sources.